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CHEMICAL & METALLURGICAL ENGINEERING

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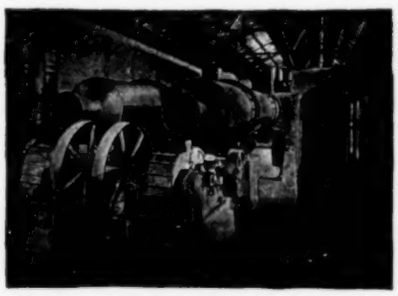

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CHEMICAL & METALLURGICAL ENGINEERING

A consolidation of
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Volume 22 — New York, February 18, 1920 — *Number* 7

Proposed Amalgamation Of Heat-Treating Societies

A WELL-DEFINED movement has been instituted looking toward the amalgamation of the American Steel Treaters' Society and the Steel Treating Research Society. It will be recollected that about two years ago the Chicago section of the Steel Treating Research Society, whose general offices were in Detroit, became dissatisfied with the conduct of the parent society and seceded, forming the American Steel Treaters' Society, with headquarters in Chicago. Some time later, under the energetic leadership of W. H. EISENMAN, business manager of the younger organization, a campaign for members was instituted which resulted in the formation of a number of new chapters, in some instances invading the territory already occupied by a local section of the Detroit body. This could not help but cause intense rivalry between the competing bodies, both local and national, and as a natural result more or less recrimination and unpleasantries passed between the partisans.

Such duplication of effort was evidently quite wasteful, and under the initiative of Professor A. E. WHITE, of the University of Michigan, both bodies appointed a committee to consider whether consolidation could be effected. This joint conference, after finding the societies financially solvent, formulated a plan of amalgamation which has now been submitted to the membership and its adoption recommended by the national officers.

Briefly, the plan contemplates a society to be named "The American Society for Steel Treating," with headquarters in Cleveland, to assume the assets and liabilities of the two founder organizations. Membership qualifications and classification are practically unchanged, while the annual dues for members are to be fixed at $10, members of the founders' societies having their membership extended a time covered by the balance of their paid-in dues. Such members will vote on the proposed consolidation, and participate in the election of new general officers.

There seems to be very little to be said against such a move for the unification of effort among heat treaters, except perhaps the individual pride which enthusiasts feel in a pet project. Even this can be well expended in making a joint association better, bigger, and more worthwhile than either one of a sharply competing pair could be.

There certainly is a world of opportunity waiting the effort of any earnest body of men who start out to correlate the scientific principles of metallurgy to the everyday technique of heat treating. In such an aim the new society should and will enjoy the undivided support of all manufacturers, metallurgists and artisans who believe in making good steel better.

The Mission Of Sir Oliver Lodge

SIR OLIVER LODGE is lecturing to capacity audiences with standing room only and applicants turned away. He has been made the subject of no little criticism from sources distinguished for scientific learning and research on the ground that he reveals nothing in physics or chemistry, hitherto unknown. Why, it is asked, does a man of his standing and achievement address himself to the elements of physics and then meander off into the imaginary field of ghosts and spooks? As a man of science, why does he not appeal to scientific men and either prove his case or quit?

We are not in sympathy with these strictures, although a diligent reading of his books and earnest attention at a number of his lectures have failed to persuade us of his conclusions. But as men of science it behooves us above all things to maintain catholic minds. We may have some curious ideas of our own perchance that would not find general acclaim if they were told to the world. Sir OLIVER is one who in the ripeness of his years has suffered a great sorrow. His investigations into psychical research had already persuaded him that communication may be held with the spirits of the dead. It seems to us a strange and unprofitable notion, but it does not seem so to him, and he is a man of great intelligence as well as a keen observer. He is entitled to his own conclusions. And he has found such comfort and solace in them that he believes others may do likewise. This is the basis of his plea.

"Our faculties," he says, "have not been developed for purposes of philosophy," and since our principal occupation is the business of living, we do not consider the ether of space. He makes a strong plea, however, for the postulate of the ether of space, and holds that without it the conductivity of light is impossible. The observation that light is affected by gravity, and is accordingly a ponderable thing, leads to the conclusion that if the ether can maintain one ponderable thing it can also maintain many others. That we have no organs to apprehend such phenomena except light and Hertzian waves does not prevent the existence of a great variety of things that may be present with us in the ether, despite all our denials. His plea is that within this medium which is to us both dark and impalpable there may exist the mystic state we know as consciousness. How consciousness can exist without all the nitrogenous paraphernalia of nerve-stuff is beyond the understanding of the writer of these lines, but Sir OLIVER'S argument is that it cannot be definitely and conclusively denied; and that is true. We know very little of consciousness anyway. Starting with this, he builds up his structure of persuasion.

Well, why shouldn't he? Science is not a close cor-

poration and its literature is not included in an *index expurgatorius*. Men of science are individuals, and they are entitled to any opinions they please to hold. Life would be dull indeed had they to march like a company of Prussian infantrymen. We have our friend Dr. JACQUES LOEB of the Rockefeller Institute, who is the protagonist of the mechanistic theory of life, and now along comes Sir OLIVER with a theory of vitalism that beats the biologists in opposition. That is as it should be. It is said of Sir OLIVER that he is a delightful companion, and we know few men indeed who are more engaging in conversation than Dr. LOEB. Both are worthy of praise for their courage to speak. Let us keep our minds open, avoid censure, and hold our hearts ever young in the hope for more light.

Reversing the In and Out Ratio of the Chemical Engineers

ABOUT twelve years ago a small group of chemical engineers held a meeting in Philadelphia and organized a society which they called the American Institute of Chemical Engineers.

In the constitution of the society they stated the objects of the organization should be:

> To advance the cause of applied chemical science.
>
> To give the profession of chemical engineering such standing before the community as will justify its recognition by municipal, state and national authorities in public works.
>
> To raise the professional standard among chemical engineers, discouraging and prohibiting unprofessional conduct.
>
> To co-operate with educational institutions for the improvement of the education of the men who are to enter this profession.
>
> To encourage original work in chemical technology.
>
> To promote pleasant acquaintance and social and professional intercourse among its members.
>
> To publish and distribute such papers as shall add to classified knowledge in chemical engineering and shall increase industrial activity.

How well the society has succeeded in accomplishing these several purposes in their fullest measure is largely open to conjecture. In the first place the membership has been so limited by rules for qualification that there are six times as many eligible men out of the society as there are in it. The non-member engineer has felt content to stay among the "six outs," while hitherto the "one in," overcome with the honor of being "all qualified," has lost sight of the real broad purposes of the society in strengthening by uniting the chemical engineering profession and done nothing toward reversing the ratio of membership. However, it may confidently be stated that a new spirit has come into the Institute and that during the present year it is planned to start a campaign to make it as alive and representative as any of the other great American engineering societies.

To do this will not mean that high standards will of necessity be disregarded, but only that they will have to be adjusted to a practical degree. This matter will be left to the council of the society to decide on in the case of each individual application for membership nomination. As the society grows in numbers, the scope of its influence will increase. It will form a nucleus around which can be rallied the very old, widely scattered, most neglected and but recently appreciated profession of chemical engineering. The society will then take on more weight and be of a wider national importance.

What To Do With Five Million

IT IS a pleasure, indeed, to learn that the Carnegie Corporation of New York has announced its purpose to give $5,000,000 for the use of the National Academy of Sciences and the National Research Council. We take pleasure in adding our congratulations to these agencies on this deserved recognition.

The suggested plan to erect in Washington a suitable home for these organizations appeals to us as a scheme worthy of support, and we trust that this program can be carried through in the very near future. Washington is more and more coming to be recognized as a world center as well as a national center for things scientific and technical. It is the logical place for certain co-ordinating and directing agencies in this field. Our Federal Government activities there, the presence of many technical organizations and societies, and the less strenuous atmosphere of a community not so intimately associated wth industrial life, all favor clear thinking, research, and sound scientific development work.

This new recognition of Washington should augment greatly the scientific life of our national capital. Particularly we hope that this new building may be so arranged as to become the real scientific center of the city. In our opinion we should find gathered in this structure the headquarters of scientific and technical organizations which maintain Washington offices. We should find there the offices of our most prominent scientific workers of various sorts who are outside the Government, and we should hope that club facilities might also be associated with this structure, possibly even to the extent of a well-appointed structure housing one of the existing clubs such as the Cosmos Club. Anyone familiar with the great advantages in New York City of the United Engineering Societies Building and the adjoining Engineers' Club knows how splendid an opportunity it affords to technical men when this combination is properly worked out. We trust that these possibilities will be very carefully considered by the management of these agencies in Washington which have been so fortunately recognized, before the exact plans and program for their new home are formulated.

Creative Engineering And Theoretical Science

ECONOMICAL attainment, next to actual accomplishment, is the most essential requisite of engineering. Therefore the ability wisely to govern expenditures of money and materials must be possessed to a high degree by all responsible engineers. This does not mean that they should be penurious individuals, spectacled ledger column totalers or the like. They should, however, have a keen perception of the effect on their work of variations in costs with changes in design and be able to adjust their plans to approach as closely as possible the most satisfactory economic solution. In cases where many of the technical details have been established by actual performance, a mass of data compiled from practice is usually available as a guide, the proper use of which will enable any designer to locate what has previously been found faulty and make suitable amendments accordingly. Most engineering practice consists of adapting well established designs to new settings with a certain amount of fault eradication thrown in for novelty. Creative engineering, on the

other hand, must start with the formulation of an economic, scientific and technical program in combination, if the enterprise is to be assured any certainty of success.

In this issue there is offered to the reader the first of a serial of four numbers entitled "The Theoretical Study of Nitrogen Fixation by the Electric Arc." It affords an excellent example of the relation of theoretical science to creative engineering. It is to be hoped that Dr. STEINMETZ by publishing these articles is giving ideas that will shortly be converted to use not alone among those interested in nitrogen fixation by the arc, but by all investigators of problems having similar factors. At the same time, it is our thought that by reviewing such a study, any readers who are by nature not followers but leaders and developers of engineering will find pleasure in this opportunity to freshen as well as to maintain their acquaintance with the astute art involved in it.

It is to be regretted that the vast majority of our technical school and college graduates regard integral and differential calculus as a sort of mental gymnastics, which upon graduation is to be abandoned along with football, baseball and other forms of vigorous effort. Many an intending reader will find himself to be a member of this majority, and if he believes he would like to become better acquainted with the ways of our eminent contributor, he would do well to provide himself with the mathematical text books the same author has written specially for engineers and get busy! The tonic effect on his mental life would be prodigious.

New York Public Library Combines Science With Technology

THE great New York Public Library on Fifth Avenue extending from Fortieth to Forty-second Street is pretty well in the heart of things. It is not set back in an academic retreat, under shady trees, inviting only scholars to enter and browse. It is visited every day by thousands of people—from 8,000 to 10,000 in fact—and most of these visitors come with a purpose. They want to know something—and usually they want to know it right away. It is a vast storehouse of books, millions of books, periodicals, pamphlets, prints and the like, and substantially everything it contains is available on demand.

Now, leaving out medicine and biology, zoölogy and botany, which are housed in other departments, the works relating to science were divided into two sections: pure and applied, or rather, as they called it, Science and Technology. Practice shows what in all modesty we have been trying for years to preach: that science and technology may not be separated. And because they constantly overlap, the sections have been consolidated. The library authorities have long felt the need of this arrangement, and now it is practically an accomplished fact. In chemistry, for example, all material relating to the subject has been brought into one large room, whether it be in regard to pressing oil from copra or to determining atomic weights.

Of course difficulties will always present themselves, and one such had to do with the problem of treating works on electricity and on electric processes—excepting electrochemistry. These have been consolidated, under the general heading of Technology. Of course all study of electricity is not technological, but the point is they shift so fast from pure science to technology that these must be kept together. For instance, the measurement of electricity was formerly a problem of pure science, whereas now it is distinctly a technological matter.

Still another difficulty was the separation of books and periodicals relating to mining and metallurgy, on the one hand, from those on geology, on the other. They were found to interlock so closely that they were brought together in the Science room. According to the general definitions, mining and metallurgy are both technological subjects, while geology, although it is as practical and as often applied as psychology, still ranks as "pure" science. The relationships, however, of the three professions are such as to make it necessary to keep them together. In short, the titles of the three divisions of Science, Technology and Chemistry are merely names. Chemistry, with approximately 10,000 volumes, is so big that it has to be housed by itself, while Science and Technology are but traditional designations that indicate the necessary separation of a department of science into fractions of the whole that would otherwise become cumbersome on account of its size. All these divisions are completely catalogued.

The relation between physics and engineering (with the exception of the field of chemical engineering, which is included in chemistry) is not close enough for the two to be consolidated, so that mathematics and pure physics still remain in the general category of Science, while all general engineering works are included in Technology. Such subjects as Military Science and Art, Agriculture, etc., are so placed as to be in stacks convenient to the section of Technology. Indeed all of these Science sections are contiguous to one another.

Scientific periodicals to the extent of about 600 titles are shelved, and index cards are made of contents, both as to subject and author. This indexing is carried out by a system whereby the current number of each periodical is not kept away from its place for over 24 hours, and check cards provide for the prompt return of numbers in use. Generally current periodicals are checked up and indexed within one week after receipt. Check cards are also kept of all books ordered.

We cannot urge too strongly upon manufacturers whose works are under scientific control the need of a proper administration of their scientific libraries. Books are useless things unless their contents are available, and neither titles nor names of authors are adequate to point to the information that is sought and frequently furnished with all the authority and accuracy of careful compilation and printing. A library is not a rest room or a sleeping apartment, neither is it properly a conference room, although we have seen a number of technological libraries that seem to be so regarded. The management of the New York Public Library is famous for its efficiency, and Mr. GAMBLE, who has charge of the general departments of Science, Chemistry and Technology, and his assistants are always both willing and disposed to give aid to those seeking information as to good library administration.

There are people not interested in libraries; their mental horizon is bounded by what man can remember. And yet it was Professor FRIEDEL of Paris who took one of his assistants by the arm and, pointing to his books, said, "Voila, mon ami! There is all I know. Books are useful instruments, and we should use them. Why should I clog my brains with a multiplicity of detail which is all set forth and easily obtained from their printed pages? But the *general principles*, my friend, these I must ever keep alive in my mind!"

Western Chemical and Metallurgical Field

Victorville Cement Mill

THE application of electric drive in the operation of a cement mill and the advantages to be derived therefrom are unusually well exemplified in the plant of the Southwestern Portland Cement Co. at Victorville, California. The town is in the southwestern part of California, about 100 miles from Los Angeles, on the Santa Fe Railroad, the tracks of which pass by the plant, affording a convenient outlet for the finished product.

The mill has an output of 300,000 bbl. a year of portland cement, and employs approximately 80 people. All of the buildings are of substantial concrete construction, built to withstand the severe conditions imposed by the heavy cement mill machinery installed.

The system of manufacture used is known as the wet process, and water for use throughout the mill is raised to a reservoir on a hill back of the plant by a 15-hp. motor-driven triplex pump.

Rock and shale are brought to the mill from the quarry, which is located seven miles distant, by steam locomotive hauling trains of cars which have two compartments or hoppers, one of which is dumped at a time to the crusher.

Electric current is purchased from the Southern Sierras Power Co., thus relieving the company of the expense and trouble incident to the operation of a power plant. Current is received at 33,000 volts and stepped down to 440 volts, for application to the various motors installed throughout the mill.

The transformers and switching apparatus are of the outdoor type, located immediately adjacent to the mill. The current is taken from here to a seven-panel marble switchboard, from which it is distributed to the various power and lighting circuits in the mill.

The lime rock is delivered from the hopper cars direct to the crusher, but a reserve pile of crushed stone, amounting to between 3000 and 5000 tons, is maintained, sufficient to keep the mill operating for a period of approximately 30 days. This reserve is maintained in the event of an accident, such as a washout, crippling the railroad service from the quarry to the mill.

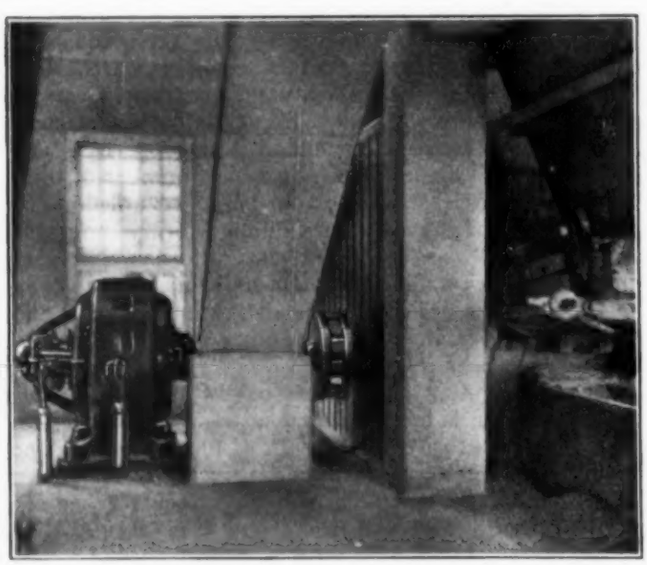


FIG. 1. 250-HP., 60-CYCLE, 700-R.P.M., 440-VOLT WESTINGHOUSE TYPE CW MOTOR DRIVING CRUSHER AND WILLIAMS MILL

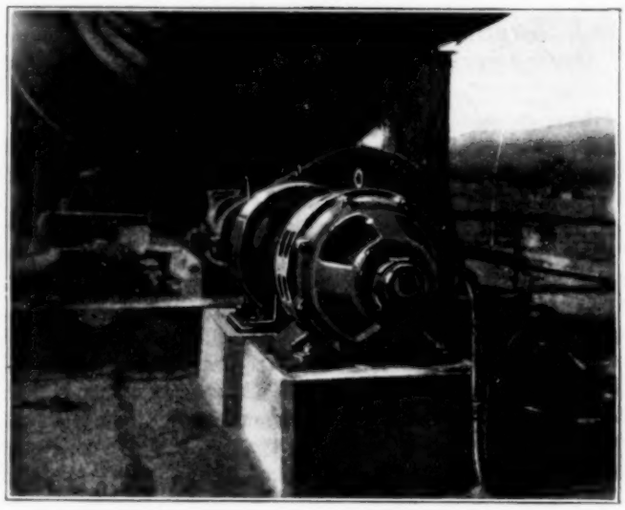


FIG. 2. 50-HP., 440-VOLT, 60-CYCLE, 3-PHASE, 700-R.P.M., MOTOR DRIVING ROTARY KILN

The crusher and Williams mill are driven by a 250-hp. Westinghouse type "CW" wound motor as is shown in Fig. 1, which breaks the rock into pieces about the side of a walnut or a little larger. From here the rock is elevated to a storage bin by a bucket elevator, driven by a 30-hp. motor, and thence by belt conveyor to the pulverizing house. Up to this time no water has been put with the rock except what is thrown on at the time it goes into the crusher, which is done with a hose to eliminate whatever dust rises at that time.

During the process of pulverization, water is added, eliminating the dust. After being thoroughly pulverized the mixture is taken to the slurry tanks, where it is kept in motion by air agitation until ready for admission to the kiln.

There are six slurry tanks, served in pairs by elevators operating at a speed of approximately 88 ft. per min., for elevating the mixture from the pulverizing house tanks. These elevators are driven by a 7½-hp. constant speed motor.

After the mixture has been thoroughly agitated it is transferred to the slurry tanks nearest the kiln. From here it flows into a sump and is delivered to the kiln by a motor-operated measuring device. The dipper is made in the shape of an "S," the outlet being in the center. By raising and lowering the dipper in the sump the amount of slurry entering the kiln can be controlled. The dipper is driven by an extended shaft, provided with two universal joints, from one of the elevators and is raised and lowered by a ¼-hp. 1725-r.p.m. motor by means of remote control from the clinker end of the kiln. A large indicator is visible to the operator at the clinker end, and he can feed the proper amount of mixture to the kiln, and control the temperature of his fire at the same time.

Fig. 3, taken from CHEMICAL & METALLURGICAL ENGINEERING, vol. 19, p. 440, shows the general layout of the kiln building, slurry tanks and burner equipment. The rotary kiln is approximately 200 ft. long and 20 ft. in diameter, lined with firebrick and heated by an oil burner to a temperature of about 2500 deg., which is measured by a radiation pyrometer. It is driven at a speed of one revolution per minute by a 50-hp. type "CW" 700-r.p.m. motor through Foote reduction gears

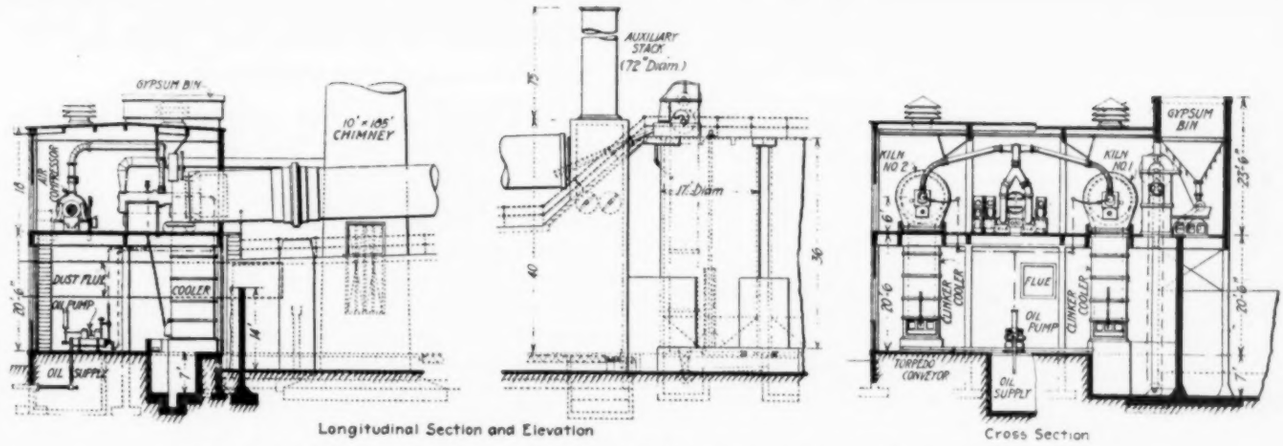


FIG. 3. LAYOUT OF KILN BUILDING, SLURRY TANKS AND BURNER EQUIPMENT

(Fig. 2). Upon coming from the kiln the clinker falls about 20 ft. into a pit to allow it to cool somewhat; it is then elevated by the clinker elevator, which is driven by the 7½-hp. 680-r.p.m. motor shown in Fig. 4 to an automatic scale and dumped into the storage bin. From the clinker storage it is transferred by means of locomotive crane with a clamshell bucket to a bin from which it is fed into a finish mill. The locomotive crane is also used for mixing the clinker, as it will vary somewhat in quality. After being ground and analyzed by the chemical laboratory, it is ready for the packing house, to which it is carried on a belt conveyor over a weighing machine, which automatically records the number of barrels that pass.

From the storage bins, the cement is taken to the sacking machines, driven by a 15-hp. motor. A sack cleaner is driven by a 7½-hp. 680-r.p.m. motor through a Foote reduction gear. A 15-hp. motor-driven blower for collecting dust from the sacking and sack cleaning machines is also used.

All motors are of Westinghouse design, alternating current, 440-volt, 60-cycle, three-phase. This plant was designed and built by Mr. L. D. Gilbert, and has been in operation over three years, during which time no shutdowns have been experienced due to any trouble with the electrical equipment. It is a model plant from every standpoint, extremely well built and practically dustless.

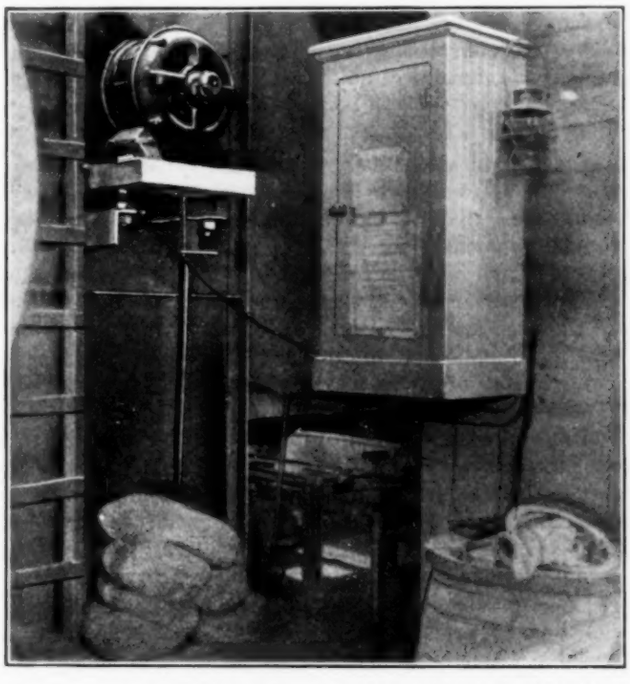


FIG. 4. 7½-HP., 680-R.P.M., 440-VOLT, 60-CYCLE, MOTOR DRIVING CLINKER ELEVATOR

It is not only an excellent plant from a mechanical standpoint and an efficient producer of high grade cement, but is notable to chemists as being the location of extensive experiments on the wet-cleaning of kiln gases for the recovery of potash. This phase of their work has already been exhaustively described by their chemical engineer, J. A. Dean, in CHEMICAL & METALLURGICAL ENGINEERING for Sept. 26, 1918, vol. 19, p. 439.

Radium Minerals

Radium minerals are generally found in connection with granitic masses—that is, in places where granite forms at least part of the rock of the country. Most of the original radium minerals, such as uraninite, samarskite and brannerite, are black and have a shiny fracture and a high specific gravity. These minerals are rarely found in commercially valuable quantities. Pitchblende, which has the same composition as uraninite and the same general appearance except that it shows no crystal form, occurs in veins. It has been found in only a few places—in Bohemia, southern Saxony, Cornwall, and Gilpin County, Col. When these original minerals break down through weathering, other radium minerals are formed from them, such as autunite, torbernite, carnotite, and tyuyamunite.

Carnotite and tyuyamunite are the most abundant of these minerals and now furnish the bulk of the world's radium. They cannot be told apart by the eye, for both are of bright canary-yellow color and are powery, finely crystalline, or, rarely, claylike in texture. Carnotite is a hydrous potassium-uranium vanadate. Tyuyamunite is similar in composition but contains lime instead of potash. The greatest known deposits of these two minerals are in southwestern Colorado and southeastern Utah, where both are associated with fossil wood and other vegetation in friable, porous, fine-grained sandstone. Small quantities of carnotite have been produced near Olary, South Australia. The only other deposits that yield tyuyamunite in notable quantity are those of Tyua-Muyun, in the Andiyan district, Ferghana Government, central Asiatic Russia (Russian Turkestan), where tyuyamunite occurs with rich copper ores in a pipe in limestone.

Dye Bill Ready for Senate

THE Senate Committee on Finance has finished its consideration of the coal-tar products bill. The form in which the bill will be reported to the Senate differs materially from the third sub-committee draft, which was discussed in CHEMICAL & METALLURGICAL ENGINEERING, Feb. 11, 1920, p. 248.

REDUCTION IN TARIFF RATES

The most striking change is the reduction in the traiff rates, the rate for commodities in Group II (intermediates) having been changed from 40 to 15 per cent *ad valorem*. Finished products, Group III, were reduced from 45 to 30 per cent *ad valorem*. The special duties of 6c. per lb. for articles in Group II and 7c. per lb. for Group III have been changed to 2½c. and 5c., respectively. The latter figure also serves as a basis for computing the duties on dyestuffs which exceed the standards of strength which shall be established by the Secretary of the Treasury.

On and after the date of passage of the act, no package containing dyestuffs shall be admitted if it or the invoice bears any false or misleading statement as to the nature of the contents.

CHANGES IN DUTIABLE LIST

With the exception of natural methyl salicylate or oil of wintergreen or oil of sweet birch, and natural coumarin, the natural products mentioned in our last issue as having been removed from Group III have been retained in that group.

SUPERVISION OF IMPORTS LIMITED TO THREE YEARS

Section 504 now provides that the Tariff Commission shall regulate the importation of coal-tar products for three years.

PRACTICE AND PROCEDURE

Section 508 has been modified in accordance with Mr. Choate's suggestions and now reads as follows:

> Sec. 508. That the United States Tariff Commission, in executing the duties imposed upon it by this act, may regulate its own practice and procedure and make all rules and regulations necessary and proper for the accomplishment of the purposes of this act: Provided, That no article enumerated in Group II or Group III of section 500 of this act shall be admitted to entry or delivered from customs custody in the United States or in any of its possessions in any case where the United States Tariff Commission shall determine that the actual consumer for whose use such article is intended has received or may obtain on reasonable terms as to quality, price, and delivery, a six months' supply of such article: And provided further, That no article enumerated in Group II or Group III of section 500 of this act which may be useful both as a substitute for a domestic article and for some other purpose for which the domestic article is not adapted shall be admitted to entry or delivered from customs custody in the United States or in any of its possessions, except when the United States Tariff Commission shall determine that such article is imported for such other purpose.

PURPOSE OF THE ACT

The concluding section of the bill states: "That it is hereby expressly declared to be the intent of the Congress in enacting this act to build up, develop and protect the dyestuffs manufacturing industry in the United States and its possessions, and that each and every of the foregoing sections shall be so construed as to effectuate such intent."

American Engineering Standards Committee

AFTER almost three years of painstaking investigation and discussion by the engineering fraternity, and under the able guidance of Prof. Comfort A. Adams as chairman, the revised constitution of the American Engineering Standards Committee, along with the by-laws and rules of procedure, has been adopted, and has been ratified by the American Society of Civil Engineers, the American Institute of Mining & Metallurgical Engineers, the American Society of Mechanical Engineers, the American Institute of Electrical Engineers, and the American Society for Testing Materials, and the three Government Departments, Commerce, Navy and War. Each of these interests have three representatives, and although the Committee as it exists today consists of twenty-four members, the new Committee is of very wide scope and allows the direct or indirect participation of anyone interested in standardization.

A. A. Stevenson is the newly elected chairman and Dr. P. G. Agnew is now permanent secretary, with headquarters at the Engineering Societies Building, 29 West 39th St., New York City.

OBJECTS

The American Engineering Standards Committee makes it possible to give an international status to approved American engineering standards and to co-operate with similar organizations in other countries. Similar organizations are now functioning in Great Britain, France, Switzerland, Holland and Canada.

Through the new Committee the methods of arriving at engineering standards will be unified and simplified and, by co-operation, the duplication of standardization work will be prevented. Standards will not be created without giving all interested an opportunity to participate.

The American Engineering Standards Committee is not only ready for business but it has made considerable practical headway, and now that the organization of the Committee has assumed such definite and precise form, no doubt its activities will be greatly extended and accelerated.

HOW THE COMMITTEE OPERATES

Any organization may request the Committee to approve standards which it has formulated, or to approve committees that it has appointed, and by so doing becomes a sponsor society.

A standard must be referred to as that of the sponsor, using whatever title the sponsor has given it, followed by the statement: "Approved by the American Engineering Standards Committee." The approval may be given in one of three ways: "Recommended Practice," "Tentative Standard" or "American Standard."

Any standard or group of standards adopted by any organization or in process of preparation, prior to Jan. 1, 1920, may be approved by the Committee, if in the opinion of the Committee it has either been developed by a properly constituted committee, or has, by actual practice, proved its right to become a standard.

The Committee will also act as a bureau of information regarding standardization. It will collect information regarding existing standards and as to the bodies that have formulated or adopted them. This will enable it to properly give the data to those who

select a committee to formulate a new standard or revise an old one.

Provision is made for direct representation on the American Engineering Standards Committee, of additional organizations (or groups of organizations) interested in engineering standardization. Already several important additional organizations of national standing have applied for membership on the Committee.

Bureau of Mines Will Investigate Tunnel Ventilation Problems

A NUMBER of inquiries have come to the Bureau of Mines in regard to the ventilation problems arising in the construction of tunnels to be used principally by motor vehicles. It is a well-known fact that the exhaust gases from such vehicles contain varying proportions of poisonous gases, especially carbon monoxide, which has caused many cases of asphyxiation in closed garages where automobile motors have been permitted to run. It is evident, therefore, that the construction of a long tunnel such as is now being designed for automobiles under the Hudson River between New York and New Jersey presents an unprecedented problem in providing adequate ventilation to render these gases harmless.

This particular tunnel will be 8,000 ft. long, and it is estimated that 2,113 motor vehicles may pass through it in one hour. The amount of gases that will be generated by these machines will be extremely large, and there are no data available on which the exact amount can be computed, because the percentage of carbon monoxide in the exhaust from gasoline engines varies with the condition of use, the load carried, the adjustment of the carburetor and other factors. The proportion of carbon monoxide can, therefore, not be determined theoretically, and the only way to arrive at figures which may be used for a basis for ventilation designs is to make a large number of tests with various types of automobiles under the different conditions to which their use in the tunnel will be subjected.

Physiological Investigations Necessary

Another important phase of this ventilation problem is the proper amount of dilution to render these exhaust gases harmless. Physiological authorities differ on the percentage of carbon monoxide that a human being may breathe without suffering any injury. Most of the information now available has to do with the effect of small percentages of carbon monoxide on miners and other workmen. Little if any consideration has been given to the effect of this gas and other constituents of exhaust gases on persons in delicate health, or to their effect on women and children. Physiological investigations should, therefore, be made from this point of view to provide information from which a figure can be determined for the proper dilution of these poisonous gases.

It is evident that the engineering design of the tunnel and arrangements for removing the deleterious or toxic gases, and the kind of ventilating apparatus, must be correlated to the quantity of production of such gases and the physiological test results.

Other Hazards in Tunnel Construction

From past experiences in driving tunnels under the Great Lakes and elsewhere, as at Milwaukee and Cleveland, it has been found that inflammable gases have been encountered and caused in one instance a disastrous explosion, killing twenty men and injuring thirteen. Other similar tunnels for water supply are now being planned. There is need of investigating the conditions in which such gases are encountered, safe methods of elimination, and protection from ignition by electric power or other causes, and the best methods of ventilation as affected by the design of the tunnel and the appliances used.

The Bureau has been called upon by certain state commissions to determine the safety and construction of certain tunnels in quicksand or water-bearing ground, the methods of bulkheading and the need of putting in air locks to prevent inrushes, and, where such bulkheads and airlocks were used, of methods of ventilation to provide for the carrying away of inflammable and deleterious gases.

There is also a need for investigating diseases of workmen caused by the presence of other deleterious gases than carbon monoxide, or by high air pressure in tunnels and shafts under water pressure, or in sinking caissons for bridge piers and buildings, especially the caisson disease, which is attributed to high air pressure. It is expected that with a better knowledge of these diseases and their causes, means of lessening or preventing them can be developed by adoption of proper methods and appliances.

Tunnels Under Consideration

The Hudson River vehicular tunnel has been mentioned because the construction work on this tunnel is to be started soon, and there is an urgent need for information on which the ventilation design may be based. There are, however, a number of other tunnel projects in various parts of the United States, among them being a vehicular tunnel through the South Hills at Pittsburgh, Pa., which will be 6,000 ft. long. Tunnel designs are also under consideration in Boston, Mass., San Francisco, Cal., and New Orleans, La. Furthermore, the time is rapidly approaching when heavy motor truck traffic will pass under the streets of large cities; such a project is now being considered for Chicago. A system for avoiding pollution of the atmosphere in such subways is urgently needed.

From the foregoing, it will appear that the problem is one of national importance, and investigative work should be commenced immediately in order that definite information may be provided on which recommendations can be made to Federal, state and municipal officials regarding methods of ventilation, physiological effects of various tunnel gases, absorbents and protective appliances for such gases, and engineering designs, in order that the atmosphere in such tunnels, shafts and other places may be made safe and healthful, not only during the construction period, but for all time, and danger from fire and explosions may be reduced to a minimum. Accordingly, it is recommended that Congress be requested to make an appropriation of $100,000 for the purpose of undertaking the work.

The immediate need for such data is further emphasized by the fact that the report of the New York commission which is studying the Hudson River vehicular tunnel has been submitted to the Governor and the Legislature. The preliminary work will probably be started about Sept. 1. The report of Chief Engineer C. M. Holland refers to the progress of the investigations being carried out under contract by the Bureau of Mines.

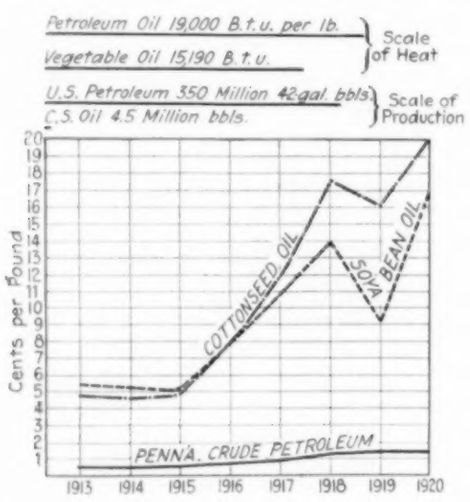
Chemical Societies Discuss Liquid Fuels

ON FRIDAY evening, Feb. 6, the New York Sections of the A. E. S., A. C. S. and S. C. I. held a joint meeting at Rumford Hall. The subject of liquid fuel was discussed. Sumner R. Church of The Barrett Co. opened the program by reviewing the various aspects of the use of coal tar for fuel. He said that some tar was being burned in open-hearth steel furnaces, especially in plants having byproduct coke oven tar available. This practice was started during the war-time fuel shortage. The sulphur content in these tars has been found to average about 0.38 per cent and they are therefore highly satisfactory for use where low-sulphur steel is required. Metallurgical coke containing less than 0.3 per cent ash, 1.0 per cent volatile and 0.11 per cent sulphur is now being made by retorting hard pitch. This coke can be used in the manufacture of high-grade electrodes. Of the tar oils, 90 per cent benzol is an important fuel, being used in making high-grade blended gasolines. As benzol freezes at 32 deg. F., it does not lend itself well for motor fuel use in the pure state. However, more than can be produced is in demand for increasing the vapor pressure of the lower cut gasolenes. Dead oil was used by the British Navy for fuel during the war. In this country it has been burned extensively for the manufacture of lampblack, but the great demand for creosotes for railroad tie, paving block and other wood preservation has made the supply of oils derived from the tar acid fractions limited.

Vegetable Oils

Dr. David Wesson next spoke on the fuel possibilities of vegetable oils. He gave comparisons between petroleum and seed oils, as follows:

The thermal values of petroleum oil and vegetable oil, the relative production of the two oils, and also the prices of cottonseed and soya bean oils for the last seven years, in comparison with the price of crude


Petroleum Oil 19,000 B.t.u. per lb.
Vegetable Oil 15,190 B.t.u.
Scale of Heat
U.S. Petroleum 350 Million 42-gal. bbls.
C.S. Oil 4.5 Million bbls.
Scale of Production
Cents per Pound
COTTONSEED OIL
SOYA BEAN OIL
PENNA. CRUDE PETROLEUM
1913 1914 1915 1916 1917 1918 1919 1920

Pennsylvania petroleum, all in cents per pound, are clearly illustrated in the accompanying chart. As you all know, Pennsylvania petroleum is the most expensive crude petroleum in the country. One doesn't have to study the figures very long to see that the quantity of cottonseed oil produced is infinitely small as compared with the amount of petroleum oil, that it is not so good a fuel as petroleum oil, and, lastly, that it costs altogether too much money. In making up this chart, no effort has been made to show the price range of soap stocks and candle pitches, as these products, taken together, do not amount to 10 per cent of the cotton oil crop. Cotton oil pitch, as a byproduct of distillation, was at one time such a drug on the market that a large company almost made up its mind to burn it under its stills, but about that time the war started up, and it was found much better to sell it and buy fuel oil, which was then selling around 75c. per bbl. of 42 gal. This material is used mostly in making roofing and paints.

It is evident from the facts already presented that there is little chance commercially of using vegetable oils for fuel so long as there is a hungry world calling for food in the form of fat.

The best equipment to use in the combustion of cottonseed, peanut, soya bean, and cocoanut and other vegetable oils is somewhat cylindrical in shape and supported on two legs. A full description can be obtained from any book on human anatomy, and the process of operation will be found in various works on physiology, or in Lusk's classic work on the Science of Nutrition.

To show how economical this apparatus is, I have made a few calculations. If you will excuse me for mentioning such a thing as a Ford, which is generally considered a very economical car, making about eighteen miles on a gallon of gasoline, we will compare its performance with the apparatus I have just mentioned. A Ford with a man in it weighs about 1,550 lb. An average man weighs about 155 lb. To move a Ford one mile there is required ⅛ lb. of gasoline, which is equivalent to 6,333 B.t.u., or 1,580 calories. A man, in walking one mile, uses up fifty-eight calories. Now, a Ford with a man in it weighs ten times as much as a man; therefore, to do the same amount of work in a Ford requires 158 calories, as against fifty-eight calories for the man. If we use cottonseed oil at the present price of 25c. a lb., it will cost 0.36c. for fifty-eight calories used in this form when fed to a man. One hundred and fifty-eight calories of gasoline fed to the Ford is equivalent to about $\frac{1}{30}$ lb. of gasoline, which, at 30c. a gal., would cost ½c. So we see that petroleum fuel, when burned in a Ford, will do twice as much work for the same amount of money as vegetable oil when burned in a man. Chemists, during the last ten or fifteen years, have done wonderful things with vegetable oils by means of hydrogenation. Let us hope that the future may see synthetic edible fats made from petroleum oil, to help cut down the high cost of living.

Alcohol as a Motor Fuel

B. R. Tunison gave an excellent review of the motor fuel situation as a whole and then spoke on alcohol as follows:

That alcohol has real value as a motor fuel no one can deny. This has been demonstrated repeatedly in this country and abroad. That it has not been a factor in this country up to the present time has been due to an economic condition rather than to inherent difficulties in its use. Petroleum products have been so plentiful and cheap that alcohol could not compete with them. But the time is not very far distant when alcohol must become a factor as a motor fuel. That alcohol cannot meet the situation immediately is readily seen from a consideration of our present alcohol production. If all the alcohol produced last year for industrial

purposes were used for fuel, it would make available for motor purposes less than 100,000,000 gal., which represents about 2.5 per cent of our fuel requirements for 1920. However, the so-called blended alcohol fuels are of importance to us at the present time. That these fuels can compete with gasoline even now is being demonstrated by the United States Post Office Department in its airplane mail service. Its tests show a great increase in the number of miles per gal., an increase in power and a very marked saving in the quantity of lubricating oil used.

The following is an analysis of the consumption of alcohol fuel at the various speeds, the tests covering thirty-one non-stop flights between New York and Washington:

R.p.m.	Gal. per Hr.
1440–1460	15.9
1475–1480	20.1
1500	21.5
1520–1525	22.44

A comparative analysis of the fuel consumption with gasoline and alcohol fuel at different engine speeds follows:

R.p.m	1440–1460	1,475	1,500
Gasoline		24	24.17
Alcohol fuel	15.9	20.1	21.5

The following is a comparative analysis of lubricating oil consumption at different engine speeds:

R.p.m	1440–1460	1,475	1,500
Gasoline		4.65	4.95
Alcohol fuel	4.5	4.2	4.2

These tests also show much less carbon formation than when using gasoline and the number of forced landings due to fouled spark plugs has been reduced to a minimum.

The U. S. Bureau of Standards has been making exhaustive tests on blended alcohol fuels, and the results of these tests are indeed indicative of the superiority of these alcohol fuels over those ordinarily obtainable. The results of these tests are available at the Bureau of Standards.

It is to be hoped that the United States Government may recognize the significance of this question and endeavor to stimulate a great increase in the production of alcohol and make possible its sale at a lower price by removing to a large extent the costly regulation of its manufacture and distribution. Alcohol should be manufactured in very large quantities and suitably denatured. Alcohol when used in blended fuels such as in admixture with petroleum distillates, benzol, etc., would naturally make a rather unsatisfactory beverage and the interests of the Government would be protected.

It is the writer's belief that this country should make a definite effort to make possible the manufacture, sale and distribution of cheap alcohol by increasing the growth of the industry so that we may benefit by the low unit cost of quantity production, by making the Internal Revenue Bureau supervisions of such a nature that the product may be handled as a cheap commodity, which it really is, instead of a $5 a gal. product as it is now being handled. The Internal Revenue Bureau is at present co-operating to a greater extent than ever before and we hope that these improvements may be made. These steps should be taken, however, before the situation becomes acute and we are forced to solve our fuel problem in the way Germany did.

It is believed that if cheap alcohol is not available the prices of the other suitable fuels will gradually rise until such times as alcohol can compete with them. Undreamed of quantities of alcohol must be produced in the future in order to protect our industries and meet the increasing demand for fuel.

Oils From Shale

Prof. Charles Baskerville closed the program with a splendid review of the possibilities of oil production from shale. He pointed out that very large-scale production would be necessary for financial success, but that a great amount of preliminary development work is now required on a small plant scale to properly test out proposed ideas of retort design and processes. He stated that shale was not a proposition for stock selling promotion schemes, will not yield quick financial returns, but if properly developed, on a conservative basis, it cannot be thought of as a gamble.

Investigation of Sulphur and Phosphorus in Steel

IT WILL be recalled that the American Society for Testing Materials, at its 1918 meeting, recognized that it would be impossible to supply the war needs of steel and yet maintain the specified sulphur and phosphorus limits because high-sulphur coal and high-phosphorus pig and scrap would necessarily have to be consumed. Consequently the limit for sulphur was horizontally raised 0.01 per cent for the period of the emergency in forty-three of its specifications, with an increase in phosphorus of a like amount for acid steels.

About a year ago the limits were again reduced in twenty-nine of these specifications, covering what might be called the special steels, such as spring steels, forging steels, and tire and wheel steels, but action on the remaining, covering tonnage materials such as rails, structural steel and plates, was deferred until 1920. It appeared essential to many parties concerned, however, systematically to procure actual data as to the effect of these elements, in addition to what was already known and published, so recommendations could be based on reliable information. Accordingly a representative committee has been appointed at the initiative of the American Society for Testing Materials, the United States Railroad Administration and the Bureau of Standards for the investigation of this important problem. Associated in the enterprise are also the Society of Automotive Engineers, Association of American Steel Manufacturers, Steel Founders Society of America, United States War and Navy Departments and Shipping Board and the National Research Council. G. K. Burgess of the Bureau of Standards is chairman and C. L. Warwick, secretary of the A.S.T.M., is secretary of the joint committee.

Organization was effected about three months ago, as noted in CHEMICAL & METALLURGICAL ENGINEERING, Nov. 5, 1919, p. 566. During this time three sub-committees have been named and have started to work. The sub-committee on statistics is headed by H. L. Whittemore, of the Bureau of Standards, and is engaged in visiting large manufacturers and users of steel, obtaining information about material high in sulphur and phosphorus which has either proved satisfactory or failed in service, and collecting samples of such material worthy of study. An investigation of the published literature is also under way.

A second sub-committee on manufacture, headed by G. K. Burgess, of the Bureau of Standards, has sub-

mitted a program of tests, and will supervise the manufacture of all metal made for this investigation. Two classes of steels will be studied—one containing moderate amounts of residual impurities, while the other will contain excessive amounts of sulphur or phosphorus added to the metal during a late stage of the manufacture. Below are the analyses to be studied in Series A.

SERIES A. RESIDUAL IMPURITIES

Group	Material	Carbon	Manganese	Phosphorus	Sulphur
1	Rivets, tubes...	0.06 to 0.12	0.35 to 0.40	0.02 to 0.03 0.04 to 0.05 0.06 to 0.07	0.03 to 0.04 0.05 to 0.06 0.07 to 0.08
2	Plates and shapes.....	0.16 to 0.22	0.35 to 0.40	0.03 to 0.04 0.05 to 0.06 0.07 to 0.08	0.03 to 0.04 0.05 to 0.06 0.07 to 0.08
3	Forgings.....	0.45 to 0.55	0.50 to 0.60	0.03 to 0.04 0.05 to 0.06 0.07 to 0.08	0.03 to 0.04 0.05 to 0.06 0.07 to 0.08
4	Rails, wheels, tires.....	0.65 to 0.75	0.60 to 0.70	0.03 to 0.04 0.05 to 0.06 0.07 to 0.08	0.03 to 0.04 0.05 to 0.06 0.07 to 0.08
5	Springs.....	0.95 to 1.05	0.35 to 0.45	0.02 to 0.03 0.04 to 0.05 0.06 to 0.07	0.03 to 0.04 0.05 to 0.06 0.07 to 0.08
6	Castings.....	Compositions not yet determined.			

It will be understood that when studying the effect of sulphur, the phosphorus is to be held as nearly constant as possible and equal to the usual value for that group of materials, and vice versa. Particular emphasis is placed on the requirement that sulphur (or phosphorus) in Series A shall be "residual," that is, sulphur present in the steels by virtue of its being contained in the pig, scrap, ore or fuel used. The opinion is held by many that high sulphur, for instance, is not harmful as such, but is indicative of other undesirable conditions in the steel, inherent in the various stages of manufacture, and that these undesirable conditions do not necessarily accompany high sulphur when the latter is obtained by addition in the ladle or mold. Thus, Unger* made a series of high-sulphur steels from three normal open-hearth heats by adding sulphide during ingot pouring, yet metal containing as high as 0.23 per cent sulphur did not exhibit any expected trouble in rolling due to hot-shortness, while the static properties suffered but slightly. Another similar series of tests on phosphorus was reported by him to the American Iron and Steel Institute in 1918. Both acid and basic open-hearth metal containing up to 0.115 per cent phosphorus gave practically the same tension tests as low-phosphorus material tested transversely to the direction of rolling, while vibratory and impact tests did not fall off as might be expected. In steels of Series B it is realized that very high sulphur probably could not be obtained without additions of extraneous sulphur-bearing material, but these will be added before reaching the mold in order not to duplicate Unger's work.

It has been decided to concentrate upon the sulphur problem first, since it presents the most urgent economic problem. The committee on manufacture has therefore supervised the manufacture of a considerable quantity of rivet steel, and will select such material as is approximately uniform in carbon, manganese and phosphorus, with sulphur varying from 0.03 to 0.08 per cent. About a ton of material of each analysis will be obtained, of which one-half will be used in testing, and the other reserved for future use.

A beginning has also been made in Series B by arranging with a large steel company for the manufacture of three heats of steel, covering groups 2, 3 and 4, from each of which eight ingots will be poured to obtain sulphur content from 0.04 up to 0.15 per cent by the addition of sulphur or pyrite in the pouring box. The upper limits are never likely to be approached in ordinary practice, but should be prosecuted to a point where the material will unquestionably fail from the effect of high impurities.

The committee on tests, headed by F. C. Langenberg, of the Watertown Arsenal, will supervise the mechanical testing. In addition to the usual standard tests of the A.S.T.M. special proof- and service-tests will be made, including, where possible, those for impact and endurance. An endeavor will also be made to determine the amount and types of gases present. The metals under investigation will be also put through fabrication processes and observed under normal service, which should give information essential to the proper interpretation of laboratory work. Under fabrication tests for the soft steel, first to be experimented upon are included such operations as flanging, punching, drifting, cold pressing and riveting. Service tests will also comprise a detailed study of such metal of abnormal analysis whose history can be definitely determined, and which has been discarded through failure or wear.

Much interest has been manifested in this investigation, which is probably unique in being the first concerted effort on the part of interested organizations to make a thorough study of a research problem of considerable magnitude. Manufacturers in particular are volunteering to furnish at their own expense the materials desired. Testing will be done by governmental laboratories, and those of large consumers, such as railroads, so there is no reason to believe that a special fund will have to be raised to defray the expenses.

Iron Age, vol. 97, p. 146.

Aluminum as an Engineering Material

At a joint meeting of the New York Section of the American Institute of Mining and Metallurgical Engineers, American Society of Mechanical Engineers and the Society of Automotive Engineers, held Feb. 10, 1920, the subject of aluminum as an engineering material was presented by a number of speakers.

The subject was not treated as a symposium on aluminum, but by independent outlines, mainly on the characteristics of the aluminum metal, its alloys and their applications, and on aluminum die castings. Graphs and micrographs were presented to show the characteristics of the different alloys, especially Al-Cu, Al-Zn, Al-Fe.

It was developed in the meeting that in the United States practically all the light alloys are aluminum-copper, whereas in Great Britain and other European countries the alloys Al-Zn predominate. This is due in part to the scant information available in America on the Al-Zn alloys. The New Jersey Zinc Co. is now doing quite extensive research work on the properties of Al-Zn alloys, and it might be expected that the results will determine whether the use of aluminum-zinc alloys will be pushed in American markets.

Aluminum die casting offers a series of difficulties, but judging from the increased number and varieties of castings produced recently it can be seen that many troubles have been overcome; it is possible now to make about 150,000 castings with a single die.

Production of aluminum is increasing rapidly and enthusiasts are prophesying that by 1930 aluminum production will equal, if not surpass, that of copper.

Theoretical Study of Nitrogen Fixation by the Electric Arc—I

Chemical Dynamics of the Nitrogen-Oxygen Reactions at the Temperatures of the Arc and During Cooling—Equations of Reaction Velocity and Temperature Equilibrium—Tables of Thermal Nitrification Constants, Reaction Periods and Velocities in Air

BY CHARLES P. STEINMETZ

THE national importance of the nitrogen fixation problem consists in the rapidly increasing demand for nitrogen fertilizers to maintain our agricultural productiveness, as the result of the enormous and increasing losses of nitrogen compounds by wastage and dissociation, which is not sufficiently compensated for by the action of the nitrifying bacteria, and the enormous amount of nitric acid required for our national defense in war emergencies, in the manufacture of high explosives.

The arc process of nitrification directly produces nitric acid, while all other processes, chemical and by-product, produce ammonia, and in a sudden emergency the former could therefore be immediately deflected to war purposes, while with the latter processes a new industry will have to be created under the war emergency, the oxidation of the ammonia produced by the fertilizer industry of peace to the nitric acid required by the manufacture of high explosives.

The arc process requires practically nothing but air, water, and electric power as raw materials; but thus far its power consumption is much higher than that of the other processes, and its industrial economy therefore still questionable. On the other hand, apparently so very little broad and general study of the arc process and its underlying phenomena, such as the characteristics of the electric arc, has been done, and there are still so many possibilities in this field that an extensive theoretical and experimental study of the problem of electric arc nitrification appears desirable.

COMMERCIAL DEVELOPMENTS

The first industrial work[1] was done by Bradley and Lovejoy on nitrogen fixation by the electric arc. After a thorough study of the conditions of nitrification by the electric arc, a plant for the production of nitric acid from the air was established at Niagara Falls. In this plant a very large number of low-current high-voltage transient arcs was used; the efficiency was good, but the cost of installation was high. Probably for this reason, and also due to the low price of Chilean nitrate at that time, the plant was not a commercial success, and had to be abandoned.

The method using a single high-power alternating current arc was developed by Birkland-Eyde. The installation made in Norway was commercially successful, has been greatly enlarged since, and a number of other arc nitrification plants have been built, using the Birkland-Eyde process or modifications thereof. Little further study seems to have been done on the arc nitrification problem in its broadest aspect, but the work chiefly consisted in developing different forms of arc furnaces, such as the Schoenherr furnace, etc., all of which, however, comprise the same principle as the Birkland-Eyde furnace, that is, a high-power, high-voltage alternating current arc moving rapidly with regard to the air acted upon by the arc. The differences between the various arc nitrifying furnaces consist chiefly in the means of producing the relative motion between arc and air: by a magnetic field, by a spiral air blast, by the heat of the arc, by a three-phase arrangement, etc.

Various other solutions of the nitrification problem have since been found and by-product coke, cyanamide and Haber processes have come into extensive industrial use, while others appear promising.

The nitrogen fixed by prehistoric plant life is recovered in the form of ammonia as by-product from coke ovens and gas works. This is now the foremost source of the ammonia supply. It is capable of enormous extension, but, due to the nature of a by-product, is not entirely unlimited.

The cyanamide process is based on the reactions:

$$CaO + 3C = CaC_2 + 3CO$$

$$CaC_2 + N_2 = CaN_2C + C$$

$$CaN_2C + 3H_2O = CaO + CO_2 + 2NH_3$$

The process is partly electrical, as the first step, the formation of calcium carbide, is carried out in the electric furnace. The electric power required for this part of the process is, however, relatively small, only about one-third to one-quarter that required by the Birkland-Eyde process of arc nitrification. It is extensively used industrially.

The Haber process of synthetic ammonia is based on the reaction:

$$N_2 + 3H_2 = 2NH_3$$

As the reaction occurs under condensation, high pressure and low temperature are favorable, but as the reaction velocity decreases with decrease of temperature, a moderate, compromise temperature, the use of a catalyzer and the highest mechanically permissible pressures are employed. This process is reported to be industrially and commercially successful in Germany.

Various other fixation precesses, as cyanide, nitride, etc., have been more or less developed.

It is interesting to note that in all fixation or recovery processes, except the arc process, ammonia is the resulting product, and to convert this into nitric acid the additional process of oxidation is required

$$4NH_3 + 5O_2 = 4NO + 6H_2O$$

and the further conversion of the NO into NO_3H in the same manner as in the arc process.

The oxidation of ammonia occurs under the influence of a catalyst, but unless the ammonia is very pure, as

[1] "Nitrogen Fixation Furnaces," CHEM. & MET. ENG., vol. 19, pp. 710-715 and 757-761.

that of the Haber process, electric heating of the catalyzer seems to be necessary to retard its poisoning by the impurities of the ammonia.

Nitrogen Fixation by the Arc

The method of nitrogen fixation by the electric arc differs from all other methods in that it requires as raw materials nothing but electric power and air and water (and some alkaline material, as soda ash, limestone, dolomite, or magnesite, if alkaline absorption is used). It is the only method which produces nitric acid directly and not through intermediary products as ammonia, calcium cyanamide, carbide, etc. It has, however, the disadvantage or requiring more electric energy per ton of fixed nitrogen, and thus far a higher plant investment than the purely chemical processes.

The reactions involved in the nitrogen fixation by the arc are:

In the arc:

$$N_2 + O_2 = 2NO \qquad (1)$$

In the cooling gas stream:

$$2NO + O_2 = 2NO_2 \qquad (2)$$

In absorption:

$$2NO_2 + H_2O = NO_3H + NO_2H \qquad (3)$$

Then, as secondary reaction:

$$2NO_2H = NO + NO_2 + H_2O \qquad (4)$$

and NO and NO_2 are again converted by equations (1) and (2), so that the final result is:

$$2N_2 + 5O_2 + 2H_2O = 4NO_3H \qquad (5)$$

Energy Required and Efficiency Obtained

The equation (1) requires per gram molecule of NO:

$Q = 21{,}600$ cal $= 91.8$ kj. (kilo-joule) of energy.

All the other reactions set energy free. Thus the total resultant reaction, (5), *sets free*, per gram molecule of NO_3H

$$Q = 7330 \text{ cal.} = 31.2 \text{ kj.}$$

According hereto, 1 kw.-hr. should produce $3600 \div 91.8 = 39.2$ g. mol. NO, giving $39.2 \times 63 = 2470$ g. NO_3H, and thereby give back 1.34 kj. as heat energy.

An industrial output of 660 kg. of NO_3H per kw.-yr., or 75 g. per kw.-hr., which seems to be a good average efficiency of the big arc process nitrate plants, thus would represent, referred to equation (1), an efficiency of about 3 per cent, while, referred to the reaction (5), the efficiency obviously is negative.

If, however, we include, in the energy required for arc nitrification, the heat energy necessary to raise the gases to the arc temperature, and assume an average specific heat of air of 0.25, and an arc temperature of 3300 deg. abs., at an NO concentration of 4.35 per cent in the arc, an additional expenditure of energy, per g.-mol., would be required, of

$$500{,}000 \text{ cal.} = 2120 \text{ kj.}$$

One kw.-hr. thus would theoretically give only 103 g. NO_3H, and the commercial output of 75 g. per kw.-hr. thus would represent an efficiency of 73 per cent.

If the heating of the air occurs at constant volume, about 25 per cent less energy would be required, giving 136 g. per kw.-hr. With arcs very quickly started and moving, probably the heating occurs between constant pressure and constant volume conditions.

Furthermore, more or less of the temperature rise of the gases could, at least theoretically, be given by regeneration.

However, the heat energy required to raise the gases to the arc temperature depends on the arc temperature, which, at least theoretically, is not a fixed invariable quantity, and on the concentration in the arc stream, so that such efficiency calculations appear of little practical value and meaning.

Scientific Study Required

It may be of interest, therefore, to study further the theoretical side of the arc nitrification problem.

As I have been interested in the problem for many years, theoretically and experimentally, such a study was undertaken. Two considerations contributed.

During the late war practically unlimited means was available to create a nitrification industry in our country, producing nitric acid for the manufacture of high explosives. Nevertheless, when the armistice was signed after a year and a half of war, I believe not a single ton of nitric acid had been produced synthetically, showing the enormous difficulty of creating a new industry rapidly on the gigantic scale required for high explosives in modern war. If it thus had been a war of defense against invasion, and the supply of Chilean nitrate had been cut off by an enemy controlling the ocean, we would have been practically defenseless. The existence of a powerful nitrification industry in peace times, which may be deflected to war uses in emergency, thus is essential for our national safety. The only demand large enough to support such an industry in peace time is that for fertilizer. However, ammonia can be used directly as fertilizer. Thus the oxidation of ammonia to nitric acid would not be required by the peace requirements, and this essential step in the war industry would remain undeveloped. Therefore the arc method of nitrification would be safer for this purpose, as its product, nitric acid, is directly applicable to the high explosive manufacture.

Furthermore, when looking into the problem of arc nitrification, it appeared that since the days of Koenig and Bradley very little general investigating has been done, and the development has all been in one direction, the use of high-power alternating arcs. Even the most fundamental data on arcs, and particularly the transient arcs used in nitrification, are very little known and uncertain, and it appears that the possibilities of development are much greater with the arc process than with any other nitrification process.

Reaction Velocity and Temperature Equilibrium

Starting with the meager available data, the reaction velocities, reaction time and thermal equilibrium conditions among oxygen, nitrogen and nitric oxide will be taken up; that is, the nitrifying action of the electric arc in air is considered and investigated as a thermal phenomenon.

The nitric oxide equilibrium concentration in air is extremely small, except at very high temperatures, and at the latter, the reaction velocity, and more particularly the dissociation velocity, is so enormous that it appears impossible to save any appreciable part of the nitric oxide from dissociation during the period of cooling, unless an extremely rapid cooling can be resorted to. The problem of thermal nitrogen fixation thus is essentially that of rapid cooling of the reacting gases.

With a given rate of cooling, or given cooling law, the maximum possible residual nitric oxide concentration, that is, the highest nitric oxide concentration in the air passing through the arc which can be saved, is limited to definite and not very high values, irrespective

of the reacting temperature in the arc, and irrespective thus of the initial nitric oxide concentration, provided the reaction temperature is higher than the equilibrium temperature of the residual concentration. Any material increase of the reaction temperature beyond the equilibrium temperature of the residual concentration possible by the cooling law thus offers no advantage, but is a waste of energy and thus of efficiency.

In the following some theoretical considerations on the arc process of nitrification are given. To a considerable extent obviously they must be of the nature of a review and very general.

In 1 g.-mol. of air, let the mol. fractions of nitrogen be n; oxygen, o; nitrogen oxides, a; and inert gas such as argon, b. Thus

$$n + o + a + b = 1 \qquad (6)$$

The normal composition of atmospheric air is $n = 0.777$; $o = 0.210$; $a = 0.000$; $b = 0.013$; so that the weight of a g.-mol. can be readily calculated from the molecular weights as follows:

Nitrogen	$= nN_2 = 0.777 \times 28 =$	21.76 g. per g. - mol. air
Oxygen	$= oO_2 = 0.210 \times 32 =$	6.72 g. per g. - mol. air
Argon	$= bAr = 0.013 \times 40 =$	0.52 g. per g. - mol. air
Air	=	29.00 g. per g. = mol. air

The volume of the g.-mol. then is, assumed as ideal gas, by $pV = RT$, in which atmospheric pressures, centimeters volume and Centigrade absolute temperatures are used.

$$V = \frac{RT}{p} = \frac{82 \times 273}{1} = 22{,}400 \text{ cc. (29 g. air)}$$

In the case of exhaust gases from an arc nitrogen fixation furnace having about 2 per cent nitric oxide content, the weight of a g.-mol. is as follows:

Nitrogen	$= 0.767 \times 28 =$	21.48 g.
Oxygen	$= 0.200 \times 32 =$	6.40 g.
Nitric oxide	$= 0.020 \times 30 =$	0.60 g.
Argon	$= 0.013 \times 40 =$	0.52 g.
Arced air	=	29.00 g.

Reaction Velocities

The velocity of combination of nitrogen and oxygen to NO may be expressed:

$$v_1 = c_1 no \qquad (7)$$

where the formation velocity constant c_1 is a function of the absolute temperature T of the reaction.

The velocity of dissociation of NO is similarly expressed:

$$v_2 = c_2 a^2 \qquad (8)$$

where the dissociation velocity constant c_2 is likewise a function of the absolute temperature T.

The rate of increase of NO is the resultant between v_1 and v_2 and is expressed

$$v = \frac{da}{dt} = v_1 - v_2 = c_1 no - c_2 a^2 \qquad (9)$$

In these equations there are three variables, n, o and a. It is frequently more convenient to denote

n_o = initial nitrogen concentration = 0.777

o_o = initial oxygen concentration = 0.210

and as

$$n = n_o - \frac{a}{2}$$

$$o = o_o - \frac{a}{2} \qquad (10)$$

the equations can be reduced to the single variable a,

$$v_1 = c_1 \left(n_o - \frac{a}{2}\right)\left(o_o - \frac{a}{2}\right) \qquad (11)$$

$$v = c_1 \left(n_o - \frac{a}{2}\right)\left(o_o - \frac{a}{2}\right) - c_2 a^2 \qquad (12)$$

Equilibrium Constants

When the rates of dissociation and combination are equal, equilibrium is reached.

$$v = c_1 no - c_2 a^2 = 0$$

$$C = \frac{c_1}{c_2} = \frac{a^2}{no} = \frac{a^2}{\left(n_o - \frac{a}{2}\right)\left(o_o - \frac{a}{2}\right)} \qquad (13)$$

or, more conveniently,

$$\sqrt{C} = \frac{a}{\sqrt{no}} = \frac{a}{\sqrt{\left(n_o - \frac{a}{2}\right)\left(o_o - \frac{a}{2}\right)}} \qquad (14)$$

The equilibrium constant C is a function of the absolute temperature T.

C, c_1 and c_2 are the equilibrium and reaction velocity constants denoted by K and k_1 and k_2 by Nernst and others, but reduced to the second as unit of time, as the second has since become the absolute time unit, while k, etc. is usually given with the minute as time unit. Thus, $C = K$, but $c = \frac{1}{60} k$. Compared with c_2, c_1 is a small quantity, the more so the lower the temperature.

The equilibrium constant C is given by van't Hoff's equation:

$$\frac{d \log_e C}{dT} = -\frac{Q}{RT^2} \qquad (15)$$

where the heat of formation of NO, Q, = − 21,600 cal. Q is claimed to be independent of the temperature and the integration of equation (15) is

$$\log_e C = \log_e \frac{c_1}{c_2} = \frac{Q}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right) = \frac{Q}{R}\left(\frac{T_1 - T_2}{T_1 T_2}\right) \qquad (16)$$

$$C_1 = C_2 e^{\frac{Q}{R}\left(\frac{T_1 - T_2}{T_1 T_2}\right)} \qquad (17)$$

From (16) substituting 21,600 for $\frac{Q}{R}$

$$\log_e C_1 = \log_e C_2 + \frac{21{,}600}{T_2} - \frac{21{,}600}{T_1} \qquad (18)$$

$$\log_{10} C_1 = \log_{10} C_2 + \frac{9380}{T_2} - \frac{9380}{T_1} \qquad (19)$$

As the average of the three determinations of Nernst gives

$$\log_{10} C = 1.048 - \frac{9380}{T} \qquad (20)$$

$$\log_e C = 2.413 - \frac{21{,}600}{T}$$

$$C = 11.17 e^{-\frac{21{,}600}{T}} \qquad (21)$$

From equation (14) then follows the equilibrium concentration

$$\sqrt{C} = \frac{a_e}{\left(n_e - \frac{a_e}{2}\right)\left(o_e - \frac{a_e}{2}\right)} = 3.34 e^{-\frac{10{,}800}{T}} \qquad (22)$$

Dr. Noyes gives $\log_{10} C = 1.091 - \frac{9426}{T}$. At 2000 deg. abs. this gives a difference of 8 deg. The values of a_o differ slightly from those given elsewhere, as in the latter the composition of air is approximated by $n_2 : o_2 = 80 : 20$ and equation (22) approximated by $\sqrt{C} = \frac{a_o}{n_o o_o}$

From Jellinek's data is calculated, by the $\Sigma\,\Delta$ method[3], the empirical equation of the dissociation velocity constant[4]:

$$\log_{10} C_2 = \bar{9}.113 + 5.731\ T\ 10^{-3} \qquad (23)$$

$$c_2 = 12.97e^{.0132\ T} \times 10^{-12} \qquad (24)$$

From (13) follows:

$$\log_{10} c_1 = \log_{10} C + \log_{10} c_2$$

thus substituting (20) and (23)

$$\log_{10} c_1 = 0.161 + 5.731\ T \times 10^{-3} - \frac{9380}{T} \qquad (25)$$

The equation $\log_{10} C = 0.814 - \frac{9460}{T}$, suggested by A. Wolokitin from hydrogen combustion, is hardly acceptable.

In Table I are given, for temperatures from 800 to 4200 deg. abs., the values of $\log_{10} C$, $\log_{10} c_1$, $\log_{10} c_2$, $\sqrt{C}$ c_2, c_1 and a_0 calculated by the equations (20), (23), (25) and (22) for air with the composition, N : O : A = 0.777 : 0.210 : 0.013. In Fig. 1, the first four of these values are plotted.

If n, o, a, are the initial concentrations per g.-mol. at time t = zero, at constant temperature T, of N_2, O_2 and NO, differing from their equilibrium values, and n_0, o_0, a_0 are these equilibrium values, and if at time t the NO concentration has increased by x (where x is negative, if $a > a_0$), the N_2 and O_2 concentrations have decreased to $\left(n - \frac{x}{2}\right)$ and $\left(o - \frac{x}{2}\right)$ respectively, when

$$\frac{dx}{dt} = c_1 \left(n - \frac{x}{2}\right)\left(o - \frac{x}{2}\right) - c_2 (a + x)^2 \qquad (26)$$

[3]See "Engineering Mathematics," by author.

[4]From the same data Dr. Noyes calculates the equation (reduced to seconds):

$$\log_{10} c_2 = 9.253 + 5.635T$$

This gives a difference at 2000 deg. abs. of 9 deg.

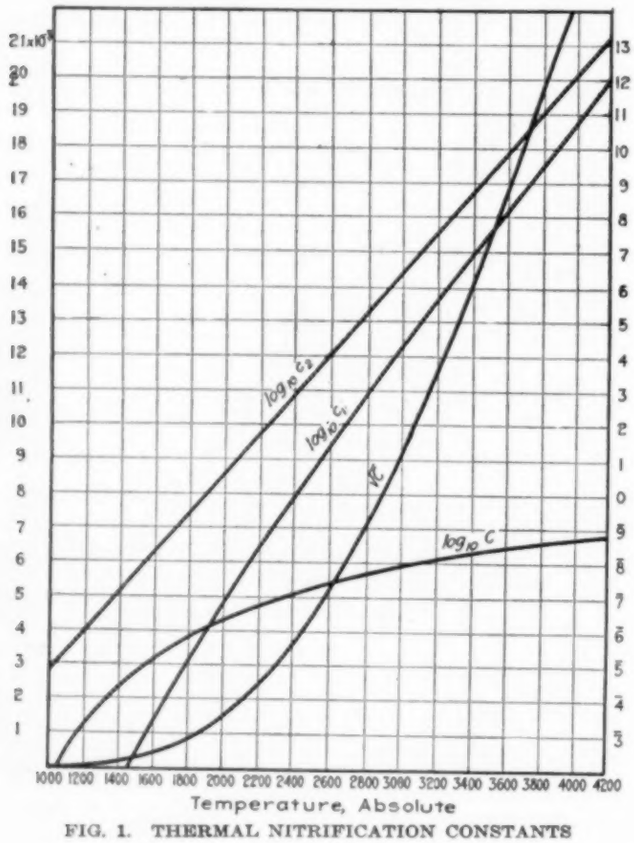


FIG. 1. THERMAL NITRIFICATION CONSTANTS

TABLE I. THERMAL NITRIFICATION CONSTANTS

Air: $N_2 = 0.777$; $O_2 = 0.210$; Neutrals = 0.013

T Deg. Abs.	$\log_{10} C$	$\log_{10} c_2$	$\log_{10} c_1$	$\sqrt{C}$ $10^{-3}\times$	c_2	c_1	a_0 % Ai
800	$\bar{9}.323$	$\bar{3}.698$	$\bar{3}.021$	0.00458	4.99×10^{-7}	1.05×10^{-17}	0.0002
900	$\bar{0}.626$	$\bar{4}.271$	$\bar{4}.897$	0.0206	1.87×10^{-6}	7.89×10^{-16}	0.0008
1000	$\bar{1}.668$	$\bar{4}.844$	$\bar{6}.512$	0.0682	6.98×10^{-6}	3.25×10^{-14}	0.003
1100	$\bar{2}.521$	$\bar{5}.417$	$\bar{7}.938$	0.182	2.61×10^{-5}	8.67×10^{-13}	0.007
1200	$\bar{3}.231$	$\bar{5}.990$	$\bar{9}.221$	0.412	9.77×10^{-5}	1.66×10^{-11}	0.017
1300	$\bar{3}.833$	$\bar{6}.563$	$\bar{0}.396$	0.824	3.66×10^{-4}	2.49×10^{-10}	0.033
1400	$\bar{4}.348$	$\bar{7}.136$	$\bar{1}.484$	1.49	1.37×10^{-3}	3.05×10^{-9}	0.06
1500	$\bar{4}.795$	$\bar{7}.709$	$\bar{2}.504$	2.50	5.12×10^{-3}	3.19×10^{-8}	0.10
1600	$\bar{5}.186$	$\bar{8}.282$	$\bar{3}.468$	3.92	1.91×10^{-2}	2.94×10^{-7}	0.16
1700	$\bar{5}.530$	$\bar{8}.855$	$\bar{4}.385$	5.82	7.17×10^{-2}	2.43×10^{-6}	0.23
1800	$\bar{5}.837$	$\bar{9}.428$	$\bar{5}.265$	8.28	2.68×10^{-1}	1.84×10^{-5}	0.33
1900	$\bar{6}.111$	0.001	$\bar{6}.112$	11.35	1.002	1.29×10^{-4}	0.46
2000	$\bar{6}.358$	0.575	$\bar{6}.933$	15.1	3.76	8.57×10^{-4}	0.61
2100	$\bar{6}.581$	1.148	$\bar{7}.729$	19.5	1.41×10^{1}	5.36×10^{-3}	0.78
2200	$\bar{6}.785$	1.721	$\bar{8}.506$	24.7	5.26×10^{1}	3.21×10^{-2}	0.98
2300	$\bar{6}.970$	2.294	$\bar{9}.264$	30.5	1.97×10^{2}	1.84×10^{-1}	1.21
2400	$\bar{7}.140$	2.867	0.007	37.2	7.36×10^{2}	1.016	1.47
2500	$\bar{7}.296$	3.440	0.736	44.5	2.75×10^{3}	5.44	1.75
2600	$\bar{7}.441$	4.013	1.454	52.5	1.03×10^{4}	2.84×10^{1}	2.05
2700	$\bar{7}.574$	4.586	2.160	61.2	3.85×10^{4}	1.44×10^{2}	2.43
2800	$\bar{7}.698$	5.159	2.857	70.6	1.44×10^{5}	7.20×10^{2}	2.8
2900	$\bar{7}.814$	5.732	3.546	80.7	5.40×10^{5}	3.52×10^{3}	3.15
3000	$\bar{7}.922$	6.306	4.228	91.4	2.03×10^{6}	1.69×10^{4}	3.54
3100	$\bar{8}.022$	6.879	4.901	102.6	7.57×10^{6}	7.96×10^{4}	3.93
3200	$\bar{8}.117$	7.452	5.569	114.4	2.83×10^{7}	3.71×10^{5}	4.35
3300	$\bar{8}.206$	8.025	6.231	126.8	1.06×10^{8}	1.70×10^{6}	4.8
3400	$\bar{8}.291$	8.598	6.889	139.8	3.96×10^{8}	7.75×10^{6}	5.25
3500	$\bar{8}.368$	9.171	7.539	152.8	1.48×10^{9}	3.46×10^{7}	5.7
3600	$\bar{8}.443$	9.744	8.187	166.5	5.55×10^{9}	1.54×10^{8}	6.15
3700	$\bar{8}.513$	10.317	8.830	180.5	2.07×10^{10}	6.76×10^{8}	6.6
3800	$\bar{8}.580$	10.890	9.470	195	7.76×10^{10}	2.95×10^{9}	7.05
3900	$\bar{8}.643$	11.463	10.106	210	2.90×10^{11}	1.28×10^{10}	7.5
4000	$\bar{8}.703$	12.037	10.740	225	1.09×10^{12}	5.50×10^{10}	7.95
4100	$\bar{8}.760$	12.610	11.370	240	4.07×10^{12}	2.34×10^{11}	8.4
4200	$\bar{8}.815$	13.183	11.998	255	1.52×10^{13}	9.95×10^{11}	8.9
∞	1.048	∞	∞	3340	∞	∞	37.6

Rearranged this equation gives:

$$\frac{dx}{dt} = (c_1 no - c_2 a^2) - 2x\left[c_2 a + \frac{c_1}{4}(n + o)\right] - \left(c_2 - \frac{c_1}{4}\right)x^2$$

or:

$$dt = \frac{-\,dx}{\left(c_2 - \frac{c_1}{4}\right)\left[x^2 + 2x\,\frac{c_2 a + \frac{c_1}{4}(n+o)}{c_2 - \frac{c_1}{4}} - \frac{c_1 no - c_2 a^2}{c_2 - \frac{c_1}{4}}\right]}$$

$$= \frac{-\,dx}{\left(c_2 - \frac{c_1}{4}\right)(x - x_1)(x - x_2)}$$

where x_1 and x_2 are the roots of the equation:

$$x^2 + 2x\,\frac{c_2 a + \frac{c_1}{4}(n+o)}{c_2 - \frac{c_1}{4}} - \frac{c_1 no - c_2 a^2}{c_2 - \frac{c_1}{4}} = o \qquad (27)$$

and are:

$$\left.\begin{matrix} x_1 \\ x_2 \end{matrix}\right\} = \frac{-1}{c_2 - \frac{c_1}{4}}\left[c_2 a + \frac{c_1}{4}(n+o) \pm S\right] \qquad (28)$$

where:

$$S = \sqrt{\frac{c_1}{4} c_2\, 4no + 2a(n+o) + a^2 + \frac{c_1}{4}(n-o)^2} \qquad (29)$$

thus:

$$dt = \frac{-\,dx}{\left(c_2 - \frac{c_1}{4}\right)(x_1 - x_2)}\left[\frac{1}{x - x_1} - \frac{1}{x - x_2}\right] \qquad (30)$$

and:

$$t = \frac{1}{\left(c_2 - \frac{c_1}{4}\right)(x_1 - x_2)} \log_e \frac{x_1 (x - x_2)}{x_2 (x - x_1)} \qquad (31)$$

and, by (29):

$$t = \frac{1}{2S} \log_e \frac{x_1 (x - x_2)}{x_2 (x - x_1)} \qquad (32)$$

is the *reaction time*, that is, the time required to change the NO concentration by x, or from a to $a + x$.

Special Cases

Dissociation of pure NO to half of its value:

$$n = 0;\ o = 0;\ a = 1;\ x = -0.5 \qquad (33)$$

For convenience, reversing the sign of x in equations (26) to (32).

In substituting (33) in (26) to (32), and neglecting c_1 compared with c_2, as a small quantity:

$$S = 0.5\sqrt{c_1 c_2}$$

$$\left.\begin{matrix} x_1 \\ x_2 \end{matrix}\right\} = + \left(1 \pm 0.5\sqrt{\frac{c_1}{c_2}}\right)$$

$$t = \frac{1}{\sqrt{c_1 c_2}} \log_e \frac{1 - x + 0.5\,x\sqrt{\frac{c_1}{c_2}}}{1 - x - 0.5\,x\sqrt{\frac{c_1}{c_2}}}$$

$$= \frac{1}{\sqrt{c_1 c_2}} \log_e \frac{1 + \frac{0.5\,x}{1-x}\sqrt{\frac{c_1}{c_2}}}{1 - \frac{0.5\,x}{1-x}\sqrt{\frac{c_1}{c_2}}}$$

and, since $\frac{c_1}{c_2}$ is a small quantity (Engineering Mathematics), the $\log_e$ becomes:

$$\frac{x}{1 - x}\sqrt{\frac{c_2}{c^1}}$$

thus:

$$t = \frac{x}{(1 - x)c_2} \qquad (34)$$

and for: $x = 0.5$

$$t_2 = \frac{1}{c_2} \qquad (35)$$

or:

$$c_2 = \frac{1}{t_2} \qquad (36)$$

TABLE II. THERMAL REACTION TIMES

T_1 Deg. Abs.	t_2 Dissociation Time of NO to half value		t_1 Formation Time of Air to half equilibr.		t_2 Dissociation Time Air, 200 Deg. Drop	
	Seconds	Hours	Years	Hours	Years	Hours
800	.....	557	18,800	....	1,670	.....
1,000	.....	39.7	114	....	18.7	164,000
1,200	10,200	2.83	1.06	9,360	0.30	2,630
1,400	730	0.203	0.0511	185	Seconds	58
1,600	52.4	....	Seconds	5.06	5,500	1.53
1,800	3.73	....	622	0.173	182	0.0505
2,000	0.266	....	24.9	....	6.3	.....
2,200	0.019	....	1.05	....	0.258	.....
2,400	1,360 micro sec.	....	0.0497	....	0.0110	.....
2,600	97.1	....	2,510 micro sec.	....	537 micro sec.	.....
2,800	6.94	....	134	....	23.0	.....
3,000	0.493	....	7.35	....	1.17	.....
3,200	0.0353	....	0.420	....	0.0632	.....
3,400	2,520 bicro sec.	....	0.0245	....	3,230 bicro sec.	.....
3,600	180	....	1,470 bicro sec.	....	175	.....
3,800	12.9	....	89.7	....	9.75	.....
4,000	0.917	....	5.56	....	0.58	.....
4,200	0.0658	....	0.349	....	....	.....

This permits to determine c_2 from the reaction time t_2.

Nitrification of Air to half the equilibrium value:

$$n = 0.777;\ o = 0.21;\ a = 0;\ x = \frac{a_o}{2} \qquad (37)$$

Substituting (37) into (26) to (32), neglecting c_1 compared with c_2, and also neglecting $\frac{x}{2}$ compared with n and o, it is:

$$S = \sqrt{c_1 c_2 no}$$

$$\left.\begin{matrix} x_1 \\ x_2 \end{matrix}\right\} = \pm\frac{1}{c_2} S = \pm\sqrt{\frac{c_1}{c_2}}\, no = \pm\sqrt{Cno}$$

and since:

$$C = \frac{a_o}{no}$$

it is:

$$\left.\begin{matrix} x_1 \\ x_2 \end{matrix}\right\} = \pm a_o$$

thus:

$$t = \frac{1}{2\sqrt{c_1 c_2 no}} \log_e \frac{a_o + x}{a_o - x} \qquad (38)$$

and for half equilibrium value, $x = \frac{a_o}{2}$:

$$t_1 = \frac{1}{2\sqrt{c_1 c_2 no}} \log_e 3 \qquad (39)$$

TABLE III. THERMAL NITRIFICATION VELOCITIES IN AIR

$$A \qquad v = \frac{dx}{dt} = c_1\left(n - \frac{x}{2}\right)\left(o - \frac{x}{2}\right) - c_2 x^2;\ n = 0.777;\ o = 0.210$$

T =	1800° $\times 10^{-6}$	2000° $\times 10^{-4}$	2200° $\times 10^{-3}$	2400° $\times 10^{-2}$	2600° $\times 1$	2800° $\times 10^{+1}$	3000° $\times 10^{2}$	3200° $\times 10^{3}$	3400° $\times 10^{4}$	3600° $\times 10^{5}$	3800° $\times 10^{6}$	4000° $\times 10^{7}$
$x = 0$	+ 0.30	+ 1.40	+ 5.23	+ 1.66	+ 4.63	+ 11.7	+ 2.75	+ 6.04	+12.65	+2.51	+4.81	+8.96
0.5	— 0.31	+ 0.44	+ 3.86	+ 1.46	+ 4.32	+ 11.2	+ 2.66	+ 5.91	+12.38	+2.47	+4.73	+8.84
1.0	— 2.39	— 2.40	— 0.19	+ 0.87	+ 3.47	+ 9.9	+ 2.47	+ 5.59	+11.95	+2.37	+4.58	+8.57
1.5	— 5.75	— 7.11	— 6.8	— 0.07	+ 2.11	+ 8.0	+ 2.17	+ 5.14	+11.21	+2.27	+4.43	+8.32
2.0	—10.44	— 13.7	— 16.1	— 1.38	+ 0.25	+ 5.3	+ 1.78	+ 4.57	+10.32	+2.14	+4.22	+8.01
2.5	— 16.5	— 22.2	— 28.0	— 3.06	— 2.14	+ 1.9	+ 1.28	+ 3.84	+ 9.23	+1.98	+3.97	+7.62
3.0	— 23.9	— 32.5	— 42.5	— 5.12	— 5.0	— 2.2	+ 0.68	+ 2.98	+ 7.98	+1.79	+3.69	+7.22
4.0	— 42.6	— 58.9	— 79.4	—10.3	— 12.4	— 12.7	— 0.83	+ 0.82	+ 4.80	+1.33	+3.01	+6.18
5.0	— 66.8	— 93.0	—127.0	—17.0	— 21.8	— 26.0	— 2.74	— 1.91	+ 0.87	+0.75	+2.16	+4.90
6.0	— 96.4	—134.0	—185.0	—25.1	— 33.3	— 42.2	— 5.07	— 5.25	— 3.90	+0.06	+1.14	+3.41
8.0	—172.0	—240.0	—333.0	—46.9	— 62.0	— 83.2	—10.95	—13.5	—15.70	—1.63	—1.30	—0.14
10.0	—268.0	—375.0	—522.0	—72.5	—100.0	—136.0	—18.4	—24.0	—30.7	—3.78	—4.37	—4.57

$$B \qquad -v = C_3 x^2$$

T =	1400° $\times 10^{-6}$	1600° $\times 10^{-4}$	1800° $\times 10^{-3}$	2000° $\times 10^{-2}$	2200° $\times 10^{-1}$	2400° $\times 1$	2600° $\times 10$	2800° $\times 10^{2}$	3000° $\times 10^{3}$	3200° $\times 10^{4}$	3400° $\times 10^{5}$	3600° $\times 10^{6}$
$x = 12$	1.97	2.75	3.86	5.40	7.53	10.5	14.5	19.9	27.4	36.8	48.5	63.4
16	3.51	4.89	6.85	9.63	13.4	18.7	26.0	36.1	50.5	69.0	93.9	128.0
20	5.48	7.63	10.7	15.0	21.0	29.3	41.0	57.1	80.0	110.5	152.0	210.0
24	7.88	11.0	15.4	21.7	30.3	42.2	59.2	82.4	116.0	161.0	223.0	310.0
28	10.7	15.0	21.1	29.5	41.2	57.7	80.7	113.0	159.0	221.0	308.0	430.0
32	14.0	19.6	27.4	38.5	53.8	75.3	106.0	148.0	207.0	290.0	404.0	563.0
36	17.8	24.8	34.7	48.8	68.2	95.3	134.0	187.0	263.0	367.0	512.0	717.0
40	21.9	30.6	41.8	60.2	84.0	117.5	165.0	231.0	325.0	456.0	634.0	887.0

Thus:

$$t_1 = \frac{1.36}{\sqrt{c_1 c_2}} \qquad (40)$$

is the reaction time producing half the equilibrium value of NO in the air.

Dissociation of NO in air from a_1 corresponding to previous temperature T_1, at lower temperature T_2, giving a_2, to half the approach to a_2, that is, to $\frac{a_1 + a_2}{2}$.

$$n = 0.777 = \frac{a_1}{2}; o = 0.21 - \frac{a_1}{2}; a = a_1; x = \frac{a_1 - a_2}{2}; \qquad (41)$$

sign of x reversed, c_1 and c_2 correspond to temperature T_2.

Substituting in equation (26) to (32), and neglecting small quantities:

$$S = \sqrt{c_1 c_2 no}$$

$$\left.\begin{matrix} x_1 \\ x_2 \end{matrix}\right\} = \frac{-1}{c_2}\left[c_2 a_1 \pm S\right]$$

$$t = \frac{1}{2S}\log_e \frac{(c_2 a_1 - S)(c_2 a_1 + S - c_2 x)}{(c_2 a_1 + S)(c_2 a_1 - S - c_2 x)}$$

$$= \frac{1}{2S}\left[\frac{2S}{c_2 a_1 - c_2 x} - \frac{2S}{c_2 a_1}\right]$$

thus:

$$t = \frac{x}{c_2 a_1 (a_1 - x)} \qquad (42)$$

and for:

$$x = \frac{2}{a_1 - a_2}:$$

$$t = \frac{a_1 - a_2}{c_2 a_1 (a_1 + a_2)} \qquad (43)$$

Thus for: $T_1 = 3840$; $a_1 = .072$

$T_2 = 2580$; $a_2 = .020$; $c_2 = 7400$

$t_2 = 1.06 \times 10^{-3}$

$= 1.06$ milliseconds.

Table II gives

t_2, the dissociation time of pure NO to half value, from (35)

t_1, the formation time of air to half equilibrium, from (40)

t_2, the dissociation time of air at 200 deg. drop, for T_2, from (43).

Table III gives the reaction velocities in air:

$$v = \frac{dx}{dt} = c_1\left(n - \frac{x}{2}\right)\left(o - \frac{x}{2}\right) - c_2 x^2 \qquad (26)$$

where: $n = .777$; $o = .210$ are the initial N_2 and O_2 concentrations respectively, and x is the NO concentration, for temperatures from 1400 to 4000 deg. abs., and NO concentrations from $x = 0$ to $x = 40$ per cent.

The second part of the table, for high concentration of NO, is calculated by the approximation permissible in this case:

$$v = -c_2 x^2$$

(Part II will be published in our next issue)

Forest Products Laboratory in Australia

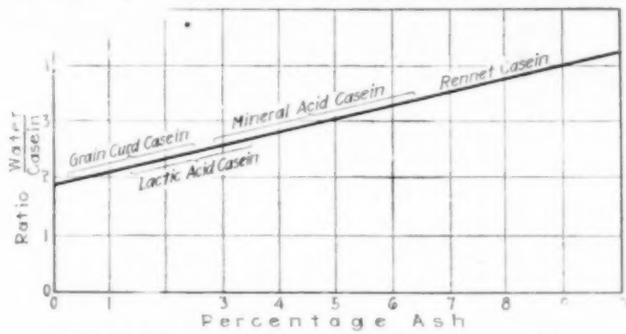
A forest products laboratory is about to be established in Australia in connection with the Perth Technical School at Perth, for the purpose of experimenting in the utilization of the byproducts of Australian timber mills and forests. I. H. Boas of the faculty of chemistry of Perth has been sent to the U. S. to conduct inquiries. He will visit the laboratories at Madison, Wis., at Montreal, and elsewhere.

Notes on Casein Glue*

It has been determined that formaldehyde used in some manufacturing processes to coagulate casein is not successful for rendering casein glue less soluble.

Discoloration of casein on heating to 212 deg. F. (100 deg. C.) is due to the presence of lactose and indicates that the curd was not very thoroughly washed. Absence of such color change indicates well-washed curd, except in the case of natural sour casein precipitated from very sour milk. In this case no discoloration is noticed, because all the lactose has been converted into lactic acid.

Proof of the value of animal, vegetable, casein and blood albumin glues as binding agents has been shown by soaking for 20 weeks in gasoline, engine oil and



ASH-WATER ABSORPTION CURVE FOR MEDIUM VISCOSITY CASEIN GLUES

castor oil, the results showing no separation of the plies. Shear tests, however, gave evidence that a gradual weakening of the glue proceeds under this treatment. The loss in strength, however, was in no case as much as would be caused by the standard test of soaking for 10 days in water.

Experiments have shown that all caseins of a reasonable degree of purity can be made into satisfactory glues by the same formula simply by varying the amount of water used.

Caseins may be divided into definite groups according to the amount of water which they require to make glue of a given consistency. This grouping is roughly the same as that according to methods of casein manufacture. Grain-curd casein requires the least water; lactic-acid casein, ordinary mineral-acid casein, and rennet casein increasingly larger amounts.

The ash content of these caseins also increases in the same order. In fact, the relation between the ash content and amount of water required is so close that if the former is known the latter may be predicted. The relation between the ash content and the water requirement may be expressed by such an equation as

$$y = mx + b$$

wherein x is the ash content of the casein, y the water-casein ratio required to give a glue of medium viscosity, and m and b constants depending upon the formula used. This gives a straight line, as shown in the diagram.

The most essential constituent used in casein to produce the casein water-resistant glue is lime. The purity of the commercial lime is not a determining factor in glue-making. When a lime of unknown analysis is to be used, it is desirable to begin with an amount which would give a glue of short- or medium-working life and a satisfactory flow. It is essential in the use of new lime that tests of the water-resistant glue products should be made as soon as possible.

*Extract from *Technical Notes*, Forest Products Laboratory

Stack Losses at Arizona Copper Co.

By J. Owen Ambler*

THE following data taken from a report submitted by the Western Precipitation Co., of Los Angeles, Cal., to Norman Carmichael, general manager of the Arizona Copper Co., Ltd., of Clifton, Ariz., show the methods and apparatus used and the results attained in testing for fume loss at the smelter of the company, and are of general interest as showing the application of the Cottrell system to this class of work. The experiments were made in 1916 and 1917.

General Method of Test

A plan of the flue system (Fig. 1) indicates the points at which samples were taken for the various departments, and during the course of the tests operating conditions were varied so that as wide a range as possible was covered. The points chosen for the tests were located so that a fairly long passage of about the same cross-section preceded the sampling, in order that the velocity figures might be as accurate as possible.

Gas samples and velocity measurements were taken at fixed points in the cross-section of the flues, explorations of this section having been made previously to determine the ratio of the velocity at the fixed point to the average over the entire flue. The entire volume passing the section was calculated from this ratio and the Pitot tube measurements of the velocity.

The volume of the gas sample was measured by a Pitot tube located in the inlet pipe between the flue and the treater, while the dust caught was collected after

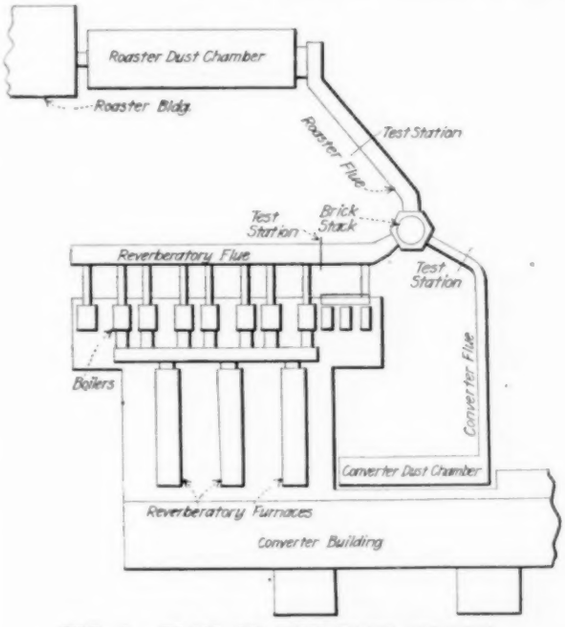


FIG. 1. PLAN OF THE FLUE SYSTEM

each run, weighed and analyzed. The weight of dust per cu.ft. of gas and the measured flue velocity were used to determine the total fume loss for the particular test.

Separation of the dust of fume from the flue gas was effected by electric precipitation in a Cottrell treater, consisting of a vertical 12-in. iron pipe (the collecting electrode) in which was suspended an iron wire (the discharge electrode). A high voltage unidirectional potential was maintained between these electrodes by means of a step-up transformer and a disk type rectifier. As is well known, when the gases with their suspended particles were passed through this treater the particles became charged, and, due to the electric field, moved to the collecting electrode, where they were deposited, the gases passing through unaffected. At the completion of a test the pipe was jarred by a blow, which caused the dust to drop to the bottom of the treater, where it was collected and weighed.

Pitot tubes used in this investigation consisted essentially of two parts, one to receive the static pressure

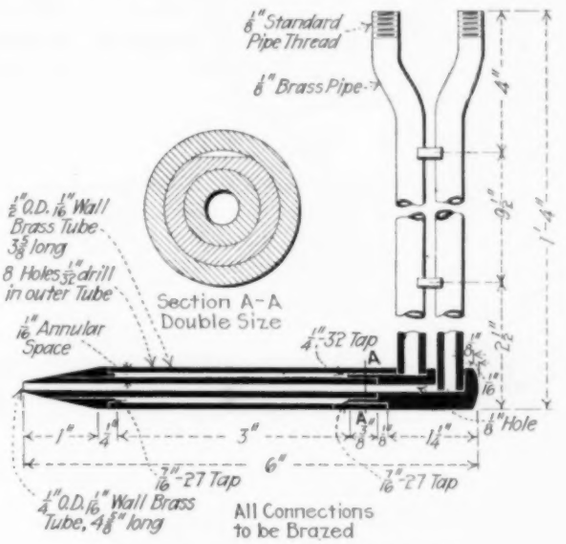


FIG. 2. DETAILS OF PITOT TUBE

and the other to receive the sum of the static and velocity pressures, the outlets from these two parts leading to the opposite ends of the gage which registered the differential pressure indicating the velocity head. The tube used was that known as the American Blower Co. type, and is shown in detail in Fig. 2. Static openings consist of small drill holes in the side of the outer sheath, and the impact opening is the end of the tube, beveled to a sharp edge. It is possible, with this type of tube and an accurate gage, to obtain an accuracy of 1 per cent, though this degree is seldom attained in general work, due to certain uncontrollable gas conditions.

Working Formula

Since in its operation the Pitot tube follows the law of falling bodies, $V^2 = 2gh$, where h is the head of fluid producing the velocity V, a working formula was developed as follows:

Let
T = absolute temperature of flowing gas, deg. F.
K = absolute temperature of flowing gas, deg. C.
P = absolute pressure of flowing gas, lb. per sq.in.
B = absolute pressure of flowing gas, in. of mercury.
d = weight per cu.ft. flowing gas at the given temperature and pressure.
G = specific gravity of flowing gas. (air = 1.)
V = actual velocity of flowing gas, ft. per sec.
h_f = height in feet of homogeneous column of gas, at given temperature and pressure, which produces V.
h = corresponding height of water column in in.
d_w = weight per cu.ft. of water = 62.37 lb. at 60 deg. F.
d_a = weight per cu.ft. of air at 32 deg. F. and 14.7 lb. = 0.08073 lb.
g = acceleration due to gravity = 32.16.

*Smelter Superintendent.

Then, $V = 1.2\sqrt{2gh_f} = \sqrt{\frac{2ghd_w}{12d}}$, since $dh_f = \frac{hd_w}{12}$.

But $d = d_a \times G \times \frac{P}{14.7} \times \frac{491.2}{T}$

Therefore, $V = \sqrt{\frac{2g\,hd_w\,14.7T}{12d_a\,491.2PG}} =$

$$\sqrt{\frac{2 \times 32.16 \times 62.37 \times 14.7 \times hT}{12 \times .08073 \times 491.2 \times P \times G}} =$$

$$\sqrt{\frac{123.9hT}{PG}} = 15.88\sqrt{\frac{hT}{BG}} = 21.30\sqrt{\frac{hK}{BG}}$$

The pressure gages were of the standard Ellison type, and both ordinary and recording mercury type thermometers were used, care being taken to insulate the treater intake pipe carefully with magnesia covering, so that the temperature taken in the intake pipe could be used both for the flue and intake temperatures.

Typical Data on Roasting Flue

A typical set of determinations in a test of the roaster flue, showing data taken and methods of calculation of results, follows:

Average velocity intake pipe	=	0.905 velocity at point of measurement
Average velocity flue	=	0.934 velocity at point of measurement
Flue velocity head	=	0.0223 in. water
Temperature	=	359.0 deg. C. abs.
Intake velocity head	=	0.1207 in. water
Barometer	=	26.47 in.
Amount dust collected	=	3607 g.
Time of test	=	920 min.
Density of gas	=	1.02
Percentage copper in dust	=	5.71

For this case with the barometer 26.47 in. of mercury the flue velocity will be:

$$21.30\sqrt{\frac{.0223 \times 359}{26.47 \times 1.02}} = 11.59 \text{ ft. per sec.}$$

Similarly the intake velocity will be:

$$21.30\sqrt{\frac{.1207 \times 359}{26.47 \times 1.02}} = 26.95 \text{ ft. per sec.}$$

Let t be the time in minutes and let v_f be the velocity in feet per second at the point of measurement in the 6-in. dia. intake pipe. The volume passing this point will be, since the average velocity is 0.905 of the velocity at point of measurement:

$$0.905 \times v_f \times \pi \times \tfrac{1}{4} \times 60 \times t = 10.68tv_f$$

$$\text{Volume of sample} = 10.68 \times 26.95 \times 920 = 265{,}000 \text{ cu.ft.}$$

$$\text{Weight of dust per cu. ft.} = \frac{3607}{265{,}000} = 0.01360 \text{ g. per cu. ft.}$$

By Pitot tube explorations of the flue the average velocity was found to be 0.934 times the velocity at the point of measurement. The dust level in the flue was determined at the beginning and completion of the test and the mean area at the section for sampling was found to be 142.5 sq.ft. If v_f is the recorded flue velocity in feet per second, the volume of gas in cubic feet per minute will be

$$142.5 \times 0.934 \times v_f \times 60 = 8{,}000v_f,$$

and total weight of dust in pounds per 24 hr. will be

$$8{,}000 \times 1{,}440 \times \text{g. dust per cu.ft.} \times v_f \times 0.002205 = 25{,}400v_f \text{ g. dust per cu.ft.}$$

By substitution, the total dust loss in roaster flue then equals

$$25{,}400 \times 11.59 \times 0.01360 = 4{,}020 \text{ lb. in 24 hr.,}$$

and the total copper loss equals

$$4{,}020 \times 5.71 \text{ per cent} = 229 \text{ lb. in 24 hr.}$$

SUMMARY OF ALL TESTS

Roasters:	Normal Draft	High Draft
Average flue velocity in ft. per sec	11.4	20.41
Average volume of gas at flue temperature, cu.ft.	91,200	163,300
Average temperature at sampling pipe, deg. F.	186	212
Average copper content of dust, per cent	5.65	5.41
Average dust loss per 24 hr., lb.	4,375	10,572
Average copper loss in 24 hr., lb.	247	571

	Operating Two Converters		Operating Three Converters
Converters:	High Draft	Normal Low Draft	High Draft
Average flue velocity, ft. per sec.	50.2	35.2	50.3
Average volume gas at flue temperature, cu.ft.	136,200	95,800	136,900
Average temperature at sampling pipe, deg. F.	349	375	400
Average copper content of dust, per cent	12.9	5.62	10.7
Average tons copper cast per 24 hr.	79.6	72.25	92.0
Average dust loss per 24 hr., lb.	1,738	1,252	2,935
Average copper loss per 24 hr., lb.	225	70.5	314

Reverberatories:	Normal Draft
Average flue velocity, ft. per sec.	19.01
Average volume gas at flue temperature, cu.ft.	259,500
Average temperature at sampling pipe, deg. F.	310
Average copper content of dust, per cent	3.58
Average tons dry solid charge treated per 24 hr.	810
Average dust loss per 24 hr., lb.	9,363
Average copper loss per 24 hr., lb.	336

RECAPITULATION

Total Copper Loss per Day—Normal Conditions

	Lb.
Roasters	247.0
Reverberatories	336.0
Converters	70.5
Total	653.5

Corporation Patriotism

Speaking at the American Electric Railway Association dinner in Cleveland on Jan. 8, Senator Harding gave the following intimate account of the way in which the du Pont organization served the War Department in the construction of powder plants.

"When America entered the war we were making in this country approximately two-thirds of all the powder used by the Allied Governments. We declared war in April, 1917, and it was nine months after the declaration before we contracted for the production of American powder to participate in the war.

"The reason was that the authorities did not want to tie up with what they termed big business, and nine months were wasted before a stroke was made, until finally the du Ponts were authorized to build a Federal powder plant at Nashville, Tenn. They were commissioned to build a plant that would produce 500,000 lb. of powder per day, and if they finished the plant and had it in running order by July 1, 1918, they were to receive a commission of $3,500,000 for the service rendered. They worked so effectively that the plant was in partial operation in June.

"The Secretary of War then called in their agents and said: 'We want to duplicate the plant. We will duplicate that contract and will extend the time to October. We want a million-pound capacity plant. Your commission will be $7,000,000 all told. Can you do it?' The spokesman for the company said: 'Yes, on one condition—that you will take out your pestiferous, uninformed, annoying inspectors, and let us do the job. We will promise you we will join in prosecuting every crook that appears on the scene, and if you will just let us do it, we will tear up our contract, and charge you not one cent bonus.'

"The Secretary of War said: 'You don't mean it?' And the spokesman said: 'We do mean it; is it a go?' The Secretary of War answered: 'Yes,' and the spokesman of the company said: 'I will tear up the contract, and $7,000,000 is our contribution toward helping the war along.'"

Some Developed Mineral Resources and Chemical Industries of the Southern States*

Review of the Southern Fertilizer Resources—Phosphate Rock, Mining, Grinding, Acidifying and Mixing Into Commercial Fertilizer—Mining of Sulphur, Pyrites and Pyrrhotite—Manufacture of Sulphuric Acid—Smelting of Copper

By ANDREW M. FAIRLIE

PHOSPHATE rock has been grouped here with three apparently unrelated minerals obviously because of the interdependence of the respective manufactured products—acid phosphate and sulphuric acid.

The object in preparing this paper is to present, in compact form, before the Institute at this meeting, held in a city of the South, some of the salient facts, already well known probably to those familiar with the subjects, pertaining to these rather prominent industries of the Southern states. A realization of what has been done in these fields of endeavor may serve as some indication of what may yet be accomplished in other fields, still undeveloped.

The term "phosphate rock" includes the calcium phosphates, of which apatite has probably the most definite and constant composition. Two varieties of apatite are recognized, namely, fluorapatite, $Ca_5(PO_4)_3F$, and chlorapatite, $Ca_5(PO_4)_3Cl$. Other phosphatic minerals are manganapatite, hydroapatite, "phosphorite," staffelite, and pseudoapatite.

A concise statement of the origin of phosphate rock, together with a description of the methods of mining (both underground and open pit), and an outline of washing and drying methods for the elimination of impurities and the preparation of the rock for the market, will be found in an article entitled "Phosphate," by E. H. Sellards,[1] obtainable from the State Geologist, Tallahassee, Fla.[2]

The United States, with a production in 1913 (the latest wholly pre-war year) of 3,111,221 long tons of phosphate rock, or practically one-half of the production of the entire world, leads all other countries as a producer of that mineral. All of this country's production, with the exception of 5,053 tons, was produced in the Southern states[3]; and Florida, with an output of 2,545,276 long tons, and Tennessee, with 451,559 long tons, together produced over 96 per cent of the entire output of the country. The only other phosphate-producing states worthy of mention are South Carolina and Kentucky, and the production in the latter state, as late as 1917, amounted to only a few thousand tons. The deposits of South Carolina were the first to be mined in America.[4] Phosphate rock has been mined in past years in Arkansas, but the production in this state has apparently stopped. Phosphatic minerals or marls are known to exist in four other Southern states—Virginia, North Carolina, Alabama and Georgia—and brief descriptions of these various deposits will be found in the paper by Sellards,[5] referred to previously.

On account of the preponderating influence on the market of the production from the states of Florida and Tennessee, the following extracts from Sellards' paper, with reference to the deposits of these two states, may be of interest.

Phosphate Deposits of Florida

"The phosphate produced in Florida includes two kinds, namely, hard rock and land pebble phosphates.

"The matrix in which the hard rock phosphate is imbedded is extremely variable. The formation includes a mixture of materials from various sources and of the most diverse character, further complicated by pronounced chemical activity within the formation itself. The prevailing phase of the formation is feebly coherent, more or less phosphatic, light gray sand. Aside from these sands the principal materials of the formation are clays, phosphate rock, flint boulders, limestone inclusions, pebble conglomerate, erratic and occasional waterworn flint pebbles, vertebrate and invertebrate fossils, and occasional pieces of silicified tree trunks.

"Phosphate rock, although the constituent of special economic interest, nevertheless makes up a relatively small part of the formation. The phosphate in these deposits occurs as fragmentary rock, boulder rock, plate rock, or pebble. The boulders are often of large size, in some instances weighing several tons, and must be broken up by blasting before being removed from the pit. It is also necessary to operate a rock crusher in connection with all hard rock phosphate mines to reduce the larger pieces of rock to a size suitable for shipping. The relative amount of material that it is necessary to handle to obtain a definite amount of phosphate is always variable with each pit and with the different parts of any one pit. The workable deposits of phosphate lying within this formation occur very irregularly. While at one locality the phosphate may lie at the surface, elsewhere it may be so deeply buried as not to be economically worked; while a deposit once located may cover more or less continuously a tract of land some acres in extent, elsewhere a deposit, appearing equally promising on the surface, may in reality be found to be of very limited extent. As to location, depth from surface, extent into the ground, lateral extent, quantity and quality, the hard rock phosphate deposits conform to no rule. The desired information

*Read before the American Institute of Chemical Engineers, Savannah, Ga., Dec. 6, 1919.

[1] E. H. Sellards, "Mineral Industries and Resources of Florida." Reprinted from the Sixth Annual Report of the Florida State Geological Survey, p. 71.

[2] Acknowledgment of indebtedness to Dr. Sellards' paper is here made for much of the data regarding the phosphate minerals and the distribution of phosphate rock, etc., repeated here.

[3] W. C. Phalen, "The Production of Phosphate Rock in 1913." Mineral Resources of the United States, Part II, 1914, p. 273.

[4] According to Sellards, actual mining began in 1867.

[5] *Op. cit.*, p. 86.

is to be obtained only by extensive and expensive prospecting and sampling.

"The materials above the phosphate deposits include pale yellow incoherent sand and in some localities clayey sand. The incoherent sands are variable, an average thickness being from 5 to 15 ft., although as much as 30 ft. have been observed.

"The land pebble phosphates of southern Florida are much more uniform in their manner of occurrence than are the hard rock deposits. The phosphate is in the form of pebble rock imbedded in a matrix of clay, sand and soft phosphate. Although variable from place to place, the phosphate bed has an average thickness of from 8 to 10 ft., its maximum thickness being from 18 to 20 ft. The overburden, which consists largely of sand and sandy clays, with local indurated or calcareous ledges, has an average thickness of from 10 to 14 ft.

"The best grade of land pebble rock, when properly washed, dried and selected, permits a guarantee of 75 or 76 per cent tricalcium phosphate. Other grades on the market range from 62 to 75 per cent. The hard rock phosphates range from 79 to 83 per cent, although selected samples run as high as 84 or 85 per cent tricalcium phosphate.

"Practically all of the hard rock phosphate mined in Florida is exported. Of the land pebble phosphate produced, over 40 per cent was exported in 1913.

Phosphate Deposits of Tennessee

"In Tennessee several more or less distinct types of phosphate occur, only two of which, however, blue rock and brown rock, are being mined at present. The blue phosphate occurs as a bedded deposit within, but forming the lowest member of, the Chattanooga formation of the Devonian age, and resting directly upon Ordovician limestone. The blue phosphates are said to vary in grade from about 30 to 85 per cent tricalcium phosphate. Iron and aluminum in the better grade of rock aggregate less than 3 per cent. The beds vary in thickness from 0 to 50 in., although the bed furnishing high-grade rock rarely exceeds 20 in. in thickness.

"The brown rock of Tennessee is at the present time (1914) of greater commercial importance than the blue rock. This rock occurs in irregular deposits lying near the surface and resting on limestone. The overburden consists usually of residual material including clay, some phosphate, and a limited amount of sand. Its thickness is extremely variab'e, although averaging 8 or 10 ft. The phosphate consists of a shelly rock, breaking up into pieces of varying size, and of small variegated pebbles which in mass have a dark brown color. Locally the small pebble rock predominates, forming a scarcely coherent mass having a brownish color. A phase of the material, known locally as 'muck' deposit, consists of a mass of small pebbles, often not exceeding a pinhead in size."

TABLE I. PHOSPHATE ROCK MARKETED IN AND EXPORTED FROM THE UNITED STATES, 1913-1917

Year	Proportion of Exports to Domestic Production (Per Cent)	Marketed Production (Long Tons)	Exports (Long Tons)
1913	44	3,111,221	1,366,508
1914	35	2,734,043	964,114
1915	14	1,835,667	253,421
1916	12	1,982,385	243,678
1917	6	2,584,287	166,003

The phosphate deposits of Tennessee are in the central part of the state. According to J. S. Hook, the centers of production lie in Maury, Hickman, Lewis, and Giles counties. The most important deposits are those in the vicinity of Mount Pleasant, in Maury county, eleven miles southwest of Columbia, the county seat. Further information regarding the phosphate rock deposits of Tennessee can be found in the April (1914) issue of "The Resources of Tennessee."[6]

Extensive deposits of phosphate rock are known to exist in Utah, Idaho, and other Western states, but as late as 1917 the West produced only 0.6 of 1 per cent of the entire output of the country for that year. That the output for 1917 (15,096 tons) represented an increase of 786 per cent over the production for 1916 indicated, however, a tendency toward increased activity in that section.

Table I[7] illustrates in eloquent manner the marked effect of the European war on the phosphate industry of this country.

The rapid decline in the exports of phosphate rock from this country is shown graphically on the accompanying diagram (Fig. 1).

Naturally, as Florida is the largest producer of phosphate rock, the brunt of the stagnation of the export

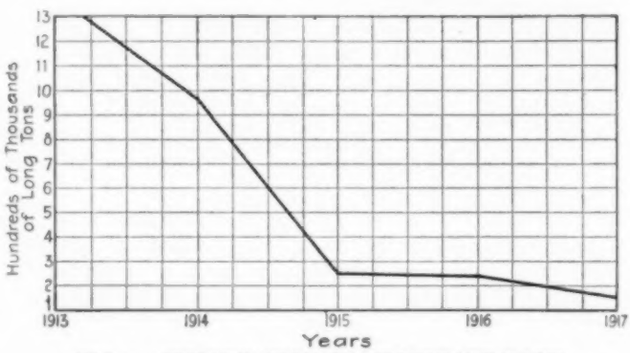


FIG. 1. EXPORTATION OF PHOSPHATE ROCK

business was borne by that state. The summary[8] of the shipments of phosphate rock from Florida from 1913 to 1918, inclusive, (Table II) is interesting, in comparison with Table I.

It is apparent, from statistics furnished by the United States Department of Commerce, that during the first half of 1919 the export business in phosphate rock showed some signs of improvement. Exportations of phosphate rock for the fiscal year ended June 30, 1919, are given in Table III.

It will be noted that all of these statistics refer to shipments. The shipment tonnages are never the same as the tonnages of rock mined, for there are variable amounts in storage at the end of each year. The tonnage of rock mined in 1918 shows a decrease of 443,247 long tons from that mined in 1917, the diminished output being a reflection of conditions due to our entry into the war, such as difficulty in securing labor, restrictions placed on fuel distribution and shipping facilities, etc.

[6] J. S. Hook, "The Brown and Blue Phosphate Deposits of South-Central Tennessee," "The Resources of Tennessee"; State Geological Survey, vol. 4, No. 2, p. 51.

[7] American Fertilizer Hand Book, 1919, p. C-6.

[8] Compiled from the American Fertilizer Hand Book, 1919, and "Statistics on Mineral Production in Florida During 1918," by Herman Gunter, State Geologist. Press Bull. No. 11, Oct. 6, 1919, p. 5.

TABLE II. SUMMARY OF SHIPMENTS (IN LONG TONS) OF PHOSPHATE ROCK IN FLORIDA, 1913-1918 INCLUSIVE

Year	Pebble Rock			Hard Rock			Pebble and Hard Rock Combined		
	Exported	Domestic	Total	Exported	Domestic	Total	Exported	Domestic	Total
1913	887,398	1,168,084	2,055,482	476,898	12,896	489,794	1,364,296	1,180,980	2,545,276
1914	625,821	1,203,381	1,829,202	303,172	6,517	309,689	928,993	1,209,898	2,138,891
1915	185,846	1,122,635	1,308,481	43,314	6,816	50,130	229,160	1,129,451	1,358,611
1916	172,427	1,296,331	1,468,758	28,045	19,042	47,087	200,472	1,315,373	1,515,845
1917	138,010	1,865,081	2,003,991	12,403	6,205	18,608*	150,413	1,872,186	2,022,599
1918	64,559	1,932,288	1,996,847	57,771	12,612	70,383*	122,330	1,932,288	2,067,230

* Includes soft rock phosphate.

The total value of the shipments in 1917 was $5,464,493, and in 1918, $6,090,106. The total production of phosphate rock in Florida since the beginning of mining it in 1888 to the close of 1918 is estimated to be 35,210,314 tons, with a total valuation of over $129,000,000[9].

The principal uses of phosphate rock are for export as such, for the manufacture of "ground phosphate rock," and for the manufacture of acid phosphate. Smaller quantities of the rock are used in other industries, such as the manufacture of matches, and the manufacture of various chemicals—phosphoric acid, ammonium and sodium phosphates, etc.

Within recent years the use of ground phosphate rock as a fertilizer has been strongly advocated, and its use has been recommended in some quarters as a substitute for acid phosphate. The producers of phosphate rock have a direct interest in promoting the demand for the raw product, which they can afford to sell for a much lower price than acid phosphate can be sold for. On the other hand, the manufacturers of acid phosphate and of sulphuric acid are directly concerned with increasing the demand for acidulated rock. Much argument has therefore arisen, pro and con, regarding the real value of ground phosphate rock as a fertilizer. As a factor tending toward a decision of the subject in dispute, by a disinterested authority, the following extract from the Georgia Department of Agriculture is to the point:[10]

TABLE III. PHOSPHATE ROCK EXPORTED FROM THE UNITED STATES, YEAR ENDED JUNE 30, 1919

Kind of Rock	Tons	Value
Land pebble	78,027	$448,855
High-grade hard rock	80,834	715,104
All other	30,227	328,575
Total	189,088	$1,492,534

"Ground phosphate rock gives very small returns in soils deficient in organic matter, hence the poor results obtained when used on clay soils. It does much better in sandy soils containing much organic matter. Soil acids and rotting organic matter are regarded as making the phosphoric acid of the rock slowly available for plants.

"The ground rock can be mixed with compost or in the manure pile, or even sowed in the furrow with six or eight times its weight of manure, and then it will give some returns. Even on cotton lands that have very little organic matter present in their soils, the use of phosphate rock is better than the entire omission of all fertilizers. But for this crop, acid phosphate will net much richer returns even if bought at much greater prices.

"It is not to be concluded from the foregoing statements that ground raw phosphate is without any value. It most assuredly is of value on certain types of soil. But the farmer should be cautioned against indiscriminate buying at extravagant prices because of extravagant claims of agents and dealers in this material."

Acid Phosphate

The first acid phosphate to be made by the modern method of treating phosphate rock with sulphuric acid was made in England in 1841.[11] The manufacture of acid phosphate is a simple chemical process. Approximately equal parts (the precise proportions being determined by the composition of the rock and the strength of the acid) of ground phosphate rock and 52-53 deg. sulphuric acid are mixed in a cast-iron pan equipped with agitators or stirrers, and the mass is then dumped into bins or "dens." The equipment of an acidulating plant consists chiefly of rock mills, screens, mixers, acid tanks, and dens. On account of the scarcity of labor the tendency among manufacturers is to adopt modern labor-saving devices, such as traveling cranes and belts, overhead trolleys or tracks, Link-Belt or Jeffrey loaders, Thew shovels, grab buckets, etc., whereby large quantities of bulk materials may be handled quickly and cheaply.

The phosphate rock is ground so that 90-98 per cent will pass through a 60-mesh screen, a weighed quantity of the "dust" is delivered, together with an accurately weighed or measured quantity of sulphuric acid of known strength, onto a mixing pan of one or two tons capacity, a usual size being 7 ft. in diameter and 2 ft. deep. The mass is stirred by mechanical stirrers until an intimate mixture is obtained, and is then dropped into dens, where it is allowed to remain for at least 12 hr. If, after a night in the den, the acid phosphate is found to be in a reasonably dry state, it is removed from the den and placed in a large pile, where it is left for 30 days or more to "condition" (during which time the excess of moisture escapes), after which the acid phosphate, or superphosphate, is ready for shipment or to be used for making complete fertilizer.

Acid phosphate will ordinarily show on analysis the following composition:

	Per Cent
Water-soluble phosphoric acid	14
Reverted phosphoric acid	2
Insoluble phosphoric acid	1

The exports of acid phosphate, for the fiscal year ended June 30, 1919, were 51,405 tons, valued at $1,548,678. It is estimated that about 4,000,000 tons of acid phosphate were manufactured in the United States in 1917, and that in 1918 about 4,500,000 tons were manufactured, the value of the product for the latter year being estimated at $76,500,000. For the manufacture of this huge tonnage of acid phosphate, large quantities of sulphuric acid have been required. But the

[9] "Statistics on Mineral Production in Florida During 1918," by Herman Gunter, State Geologist. Press Bulletin No. 11, Oct. 6, 1919, p. 5.

[10] Bulletin No. 76, Georgia Department of Agriculture, 1918, p. 40, ff.

[11] Sellards, *op. cit.*, p. 87.

sulphuric acid industry is dependent on the mineral industry for its principal raw material, and the development of the pyrite and sulphur deposits of the South has resulted from the demand for sulphuric acid.

SULPHUR

Up to the year 1918, two companies, the Union Sulphur Co., Sulphur, Calcasieu parish, La., and the Freeport Sulphur Co., near Freeport, Brazoria county, Tex., produced more than 99 per cent of the sulphur mined in the United States. A small amount of sulphur was produced in three Western states—Nevada, Wyoming and Colorado—but it is noteworthy that without the product from the Southern states named the output of brimstone from the United States was practically nil. During 1918 a third large producer—the Texas Gulf Sulphur Co., whose plant is at the mouth of the Colorado River, at Matagorda, Tex.—and again a Southern one, entered the field.

The production of brimstone in the United States for the year 1918 was reported as 1,352,283 tons.[12] The estimated production for 1917 was given as 1,137,000 tons. The tonnage for 1917 was said by the United States Geological Survey to have been nearly 50 per cent greater than in 1916, while during that year the production of brimstone was several hundred per cent greater than in any year before the war.[13]

The character of the sulphur deposits in the Southern states has been described by Philip S. Smith.[14] As is well known, these deposits are mined by the ingenious process developed by Herman Frasch. The original Frasch patent of Oct. 20, 1891, having expired and the later patents having recently been declared invalid,[15] the process, heretofore considered to be an exclusive one, appears now to be open to general use.

Besides the manufacture of sulphuric acid, the principal use of sulphur is in the manufacture of paper. Smith[16] states that paper manufacturers report a consumption of one-eighth of a ton of sulphur for each ton of sulphite pulp manufactured. According to census returns, the sulphite pulp industry in the United States consumed 136,456 short tons of sulphur in 1914.

Prior to the war, very little sulphur was used in this country for the manufacture of sulphuric acid. But owing to the combined effect of increased demand for acid for the manufacture of munitions and the diminished supply of ships for the transportation of pyrites from Spain, the quantity of sulphur used for the manufacture of sulphuric acid has very greatly increased. The producers of acid report that 463,364 long tons of domestic sulphur were used by them in 1917.[17] Obviously, most of this must have come from the South.

PYRITES

Pyrites, or pyrite, whose main use is for the manufacture of sulphuric acid, was prior to the war imported into the Southern states in large quantities from Spain. The exigencies of the war stopped most of this importation, and it was expected that the production of domestic pyrites would be greatly stimulated.

Virginia takes first rank among the states as a producer of pyrite, both as to quantity and value of output. In 1916 this state produced 148,502 long tons, valued at nearly one million dollars. Virginia's production in 1917 was 170,382 long tons. According to the Virginia State Geological Survey, the pyrite producers at present are:

The American Agricultural Chemical Corp., operating the Cabin Branch mines, Prince William county.

Grasselli Chemical Co., operating the Arminius mine, Louisa county.

Sulphur Mining & Railroad Co., operating a mine three miles north of Mineral, Louisa county.

The General Chemical Co., operating a mine at Monarat, Carroll county.

Two mines in Louisa county, one owned by the Armour Fertilizer Co. and the other by Boyd-Smith Mines, Inc., were reported not operating in 1919. The Ohio Sulphur Mining Co., operating near Proffit, Albemarle county, reported development work in progress, and the Western Pyrites Corp., operating near Garrisonville, Stafford county, reported that it expected to resume production about the first of December.

Among the Southern states, Georgia ranks second as a producer of pyrite. Georgia contributed 23,242 long tons in 1917. Besides Virginia and Georgia, the Southern states producing were Alabama, Kentucky and Tennessee.

The total production of domestic pyrites in 1917 was reported by the United States Geological Survey as 462,662 long tons, an increase of 10 per cent over the 1916 production. The expected increase in pyrites production for the year 1918 did not materialize. This failure is attributed to the difficulty in securing labor, to the war-time restrictions placed on the delivery of mining equipment and other supplies, etc. The production for 1918 was estimated at 453,637 long tons[18], about 10,000 tons less than in 1917, or a loss of about 2 per cent.

PYRRHOTITE AND COPPER SULPHIDES

Pyrrhotite, while it is, like pyrite, an iron sulphide, is considered separately, as it is found associated with copper sulphides and has been treated along with the copper sulphides, primarily for the recovery of copper. The method of producing the sulphur dioxide from the sulphur, applied to these ores, is different from the method applied to pyrite. Otherwise the process of making the acid is practically the same.

The pyrrhotite deposits used for the manufacture of sulphuric acid and found associated with the sulphides of copper are mined in the Ducktown district in the southeastern corner of Tennessee, just north of the Georgia line and just west of North Carolina. These deposits have been worked for many years for their copper values, and since 1907 sulphuric acid has been made as a byproduct from the escaping fumes of the copper blast furnaces. There are two companies operating in the district—the Ducktown Sulphur, Copper & Iron Co., Ltd., and the Tennessee Copper Co.—and the total tonnage of ore mined annually by the two companies is in the neighborhood of half a million tons. The developed ore reserves at the mines of these companies is sufficient to permit the continuance of operations at the above rate for a number of years.

The process of smelting is the usual one for copper-iron sulphides, and consists of two operations: (1) smelting the ore in blast furnaces (in either one stage

[12] American Fertilizer Hand Book, 1919, p. 34.

[13] Philip S. Smith, "Sulphur, Pyrite and Sulphuric Acid in 1917." Mineral Resources of the United States, 1917, Part II, p. 19.

[14] Philip S. Smith, *ibid.*, p. 22.

[15] "Sulphur Mining Freed of Patent Monopoly," *Chemical Age*, July, 1919, p. 33.

[16] Philip S. Smith, *op. cit.*, p. 23.

[17] Philip S. Smith, *op. cit.*, p. 23.

[18] American Fertilizer Hand Book, 1919, p. 32.

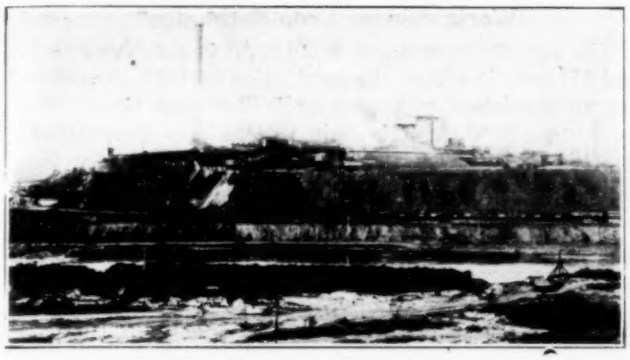


FIG. 2. GASES ESCAPING AT THE TENNESSEE COPPER CO. PLANT

or two stages) for copper matte, containing 30 to 40 per cent Cu; (2) blowing the matte to blister copper in basic lined converters. The amount of copper marketed is about 13,000,000 to 14,000,000 lb. annually.

Sulphuric Acid

According to the United States Geological Survey, the numbers of sulphuric acid plants operating in the several Southern states in 1916 were as follows:

Alabama	12	Mississippi	5
Arkansas	1	North Carolina	12
Florida	5	Oklahoma	1
Georgia	30	South Carolina	15
Louisiana	3	Tennessee	6
Maryland	11	Texas	3
		Virginia	9
Total, Southern states			113
United States (1917)			221

As fifteen plants were undistributed, the above total for the Southern states is probably slightly too low. The value of the acid produced in Virginia, Maryland and Georgia in 1917 was more than $5,000,000 for each state.

During 1917 and 1918 many new sulphuric acid plants were built in the Southern states, some of them of unusual size. A chamber plant of 600 tons daily capacity had been barely completed at Little Rock, Ark., when the armistice was signed, and had not yet been put into operation. At Brunswick, Ga., a chamber plant for the manufacture of 800 tons per day of 60 deg. Bé. acid was 40 per cent completed on Nov. 11, 1918, but work on the plant was stopped after the signing of the armistice. A large contact plant at Nashville, Tenn., was 75 per cent completed on the day of the armistice, and construction work on this plant also has been stopped.

Even before these large plants were designed, however, the South already had the largest sulphuric acid plant in the world—larger than either the Little Rock or the Brunswick plant—in the 6,500,000 cu.ft. of chamber space owned and operated by the Tennessee Copper Co., at Copperhill, Tenn. The average daily capacity of this plant is 1,000 tons (60 deg. Bé.), but the output often falls short of this amount, owing to fluctuations in the supply of gas. It has produced, for ten consecutive days, a daily average of 960 tons of 60 deg. Bé. acid, and there have been single days when over 1,100 tons of acid were reported.

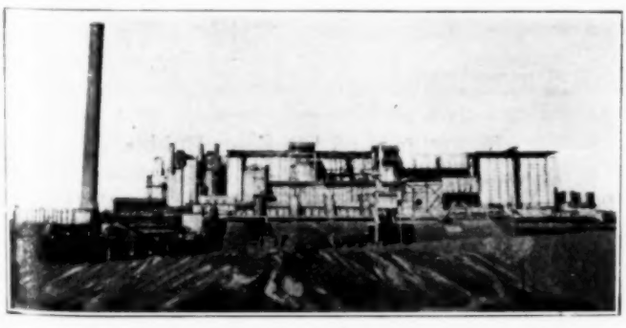


FIG. 3. FUMELESS OPERATION AT THE TENNESSEE COPPER CO.

For a long time the plant operated on the waste fumes of the copper blast furnaces only. Up to this year, no practical means had been developed of utilizing the waste fumes of the copper converters, and the equivalent of fifty tons or more daily of sulphur had for a long time escaped. Recently it has been found possible to utilize the converter gas, in addition to the blast-furnace gas, without any addition whatever to the size of the acid plant. The gases from both sources (furnaces and converters) are combined in one common flue, and by means of lead fans of unusual size are drawn into the capacious chambers, and are there condensed into acid. By this means practically all the sulphur volatilized, by furnaces and converters, is recovered as acid. The sulphur recovery for the months of October and November this year was 90 per cent, based on total sulphur volatilized. Since a recovery of 95 per cent of the sulphur, for a plant built exclusively for the purpose of making sulphuric acid, is considered good practice,

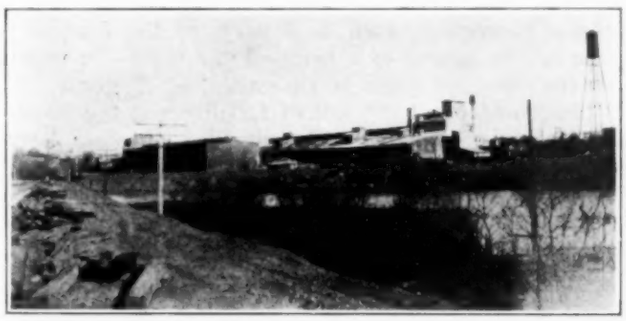


FIG. 4. ARMOUR ACID PHOSPHATE PLANT

it is apparent that the sulphur loss at this huge byproduct plant is approaching an irreducible minimum. The dense white fumes, formerly seen escaping from the tall chimney, the irritating gases, which in past years had swept the furnace charging floors, a detriment to successful furnace operations and a serious handicap to the furnace tenders, are today conspicuous by their absence. The atmosphere in the vicinity of the smelter is almost entirely free from sulphurous gas, and the 325-ft. chimney, which formerly poured forth vast volumes of sulphurous gases, stands today cold and empty—a monument to the waste of the past. The accompanying photograph (Fig. 2) illustrates the effect "before," Fig. 3 shows the effect "after," instituting the recent improvements in operating methods.

Fertilizer

As the manufacture of acid phosphate is dependent on the sulphuric acid industry, so the vast fertilizer business of the United States is dependent on the acid phosphate industry. The three largest manufacturers of chemical manures are the American Agricultural Chemical Corp., the Virginia-Carolina Chemical Co., and the International Agricultural Corp. Most of the plants of these concerns are located in the Southern states, and in addition there are scattered throughout the South

many fertilizer plants owned and operated by the well-known meat packing concerns—Swift, Morris and Armour—as well as many owned by independent concerns, some large, such as the Royster Guano Co., and some smaller ones.

The manufacture of complete fertilizer consists in mixing acid phosphate in suitable proportions with nitrogenous materials, such as dried blood, tankage, fish scrap, or cottonseed meal, and potash salts. Sometimes the nitrogen or the potash is omitted, in which case the product becomes either "alkaline goods" (acid phos-

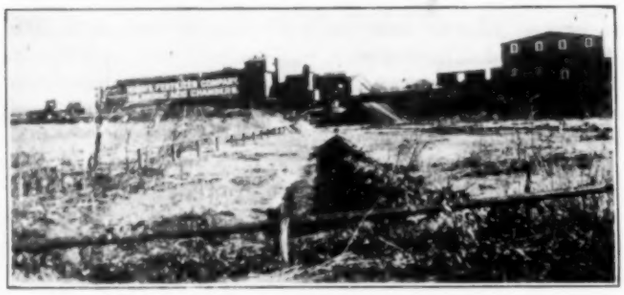


FIG. 5. MORRIS & CO. FERTILIZER PLANT

phate with potash) or "ammoniated superphosphate" (acid phosphate with nitrogenous material).

The complete fertilizer containing phosphoric acid, nitrogen, and potash, contains these ingredients in some definite proportion, such as 8 parts of the first to 2 parts of the second to 2 parts of the third—in which case the fertilizer would be known as "8-2-2" grade.

The manufacture and sale of fertilizers in the Southern states is regulated and controlled by state laws, supported by state chemists and their laboratories.

Table IV shows the amount of fertilizers consumed in the Southern states in 1918, compared with the total consumption for the United States.

TABLE IV. CONSUMPTION OF FERTILIZERS IN THE SOUTHERN STATES AND IN THE ENTIRE U. S. FOR THE FISCAL YEAR ENDED IN 1918*

States	Tons Consumed	States	Tons Consumed
Alabama	289,990	Mississippi	104,700
Arkansas	88,500	North Carolina	921,962
Florida	197,954	Oklahoma	25,000
Georgia	923,020	South Carolina	1,064,886
Kentucky	128,000	Tennessee	113,000
Louisiana	81,025	Texas	58,000
Maryland	173,000	Virginia	430,549
Total, South			4,599,586
United States			6,991,743

*Compiled from American Fertilizer Hand Book, 1919, page 20.

Figs. 4 and 5 show the Armour Co. and Morris & Co. fertilizer plants, both of Atlanta. In each case, the sulphuric acid plant can be seen at the left.

The statistics given will serve to show the magnitude of these industries of the South. There are many other Southern industries—mineral, chemical, and metallurgical—which will compare, as to capital involved and value of product, with the phosphate, sulphuric acid, and fertilizer industries, and some, perhaps, will surpass these. The coal and iron of Alabama, the coal of Kentucky and Tennessee, the marble of Tennessee and Georgia, the oil of Oklahoma and Texas, the naval stores and cottonseed oil industries, the hardwood industries of the Appalachians—a study of all these would prove profitable to those who are interested in the progress of the South.

504 Citizens & Southern Bank Bldg.,
Atlanta, Ga.

World's Sugar Crop Estimates*

The world's cane-sugar of 1918-19 is estimated to be 340,371 tons less than the production of 1917-18, according to the latest estimates of Willett and Gray. The beet-sugar production is estimated to have decreased by 642,184 tons, making a total estimated sugar shortage of 982,555 tons, as compared with 1917-18. Tables I and II give the final statistics for the years 1916-17 and 1917-18, and the estimates for 1918-19.

TABLE I. CANE SUGAR PRODUCTION

	1916–17, Tons	1917–18, Tons	1918–19 Tons
United States:			
Louisiana	271,339	217,499	250,802
Texas	6,250	2,009	3,125
Porto Rico	448,567	405,174	375,000
Hawaiian Islands	575,510	515,035	520,000
West Indies—			
St. Croix	7,787	5,400	6,500
Cuba	3,023,720	3,446,083	4,000,000
British West Indies:			
Trinidad	70,891	45,256	50,000
Barbados	55,456	65,230	80,000
Jamaica	28,331	34,300	40,000
Antigua	17,046	9,409	11,900
St. Kitts	15,048	8,846	10,000
Other	7,906	16,745	10,000
French West Indies:			
Martinique (exports)	31,443	20,881	35,000
Guadeloupe	36,160	28,000	25,000
Dominican Republic	130,171	145,000	165,000
Haiti	.....	.....	18,000
Mexico	50,000	40,000	40,000
Central America	25,000	25,000	30,000
South America:			
Demerara (exports)	101,650	114,007	93,902
Surinam	12,000	10,000	12,000
Venezuela (exports)	18,428	15,000	15,000
Ecuador	7,000	8,000	7,000
Peru	276,000	265,000	250,000
Argentina	87,699	130,266	240,000
Brazil	150,051	148,958	260,000
Total in America	5,456,453	5,721,107	6,548,229
British India (consumed locally)	2,728,000	3,311,000	2,337,000
Java	1,596,174	3,311,000	2,337,000
Taiwan and Japan	436,026	397,618	415,678
Philippine Islands	202,655	216,260	150,000
Total in Asia	4,962,855	5,715,942	4,572,315
Australia	192,831	325,900	226,000
Fiji Islands	95,900	70,800	80,000
Total in Australia and Polynesia	288,731	396,700	306,000
Egypt	101,832	79,450	82,000
Mauritius	209,035	225,466	252,000
Reunion	42,152	50,000	50,000
Natal	114,494	106,250	144,000
Mozambique	55,000	50,000	50,000
Total in Africa	522,513	511,166	578,000
Europe: Spain	4,584	6,000	6,000
Total cane-sugar crops	11,235,136	12,350,915	12,010,544

TABLE II. BEET SUGAR PRODUCTION

	1916–17, Tons	1917–18, Tons	1918–19 Tons
Europe:			
Germany	1,603,920	1,570,578	1,411,900
Czechoslovakia, etc	944,500	668,250	700,000
France	184,191	200,265	109,783
Belgium	135,031	131,000	75,000
Netherlands	269,180	199,295	164,981
Russia, Ukraine, Poland, etc	1,321,600	1,028,580	700,000
Sweden	150,000	125,000	119,000
Denmark	112,800	115,000	115,000
Italy	140,000	110,000	100,000
Spain	125,540	134,955	135,000
Switzerland	4,000	4,000	4,000
Bulgaria	15,000	11,000	8,000
Total in Europe	5,005,762	4,287,923	3,642,664
United States	734,577	682,867	674,892
Canada	12,500	11,250	22,300
Total beet-sugar crops	5,752,839	4,982,040	4,339,856
Grand total cane and beet sugar	16,987,975	17,332,955	16,350,400

Importance of the Soap Bubble

R. S. Williams calls attention in the *Journal* of the Society of Chemical Industry in an article on the theory of flotation to the fact that the forces at work in a soap bubble are of such technical importance that 60,000,000 tons of ore are annually treated by their application.

**Fortnightly Information Review* of American Chamber of Commerce in France, Sept. 15, 1919, p. 273.

Some Aspects of Cheap Cyanide Processes*

Review of the Developments Made in Cyanide Synthesis—Improvements Made in the Ferrocyanide Process—Reactions Between Nitrogen, Carbon and Alkaline Bases—Fixation in the Electric Arc—Cyanamide Process

BY HERBERT PHILIPP
Consulting Chemical Engineer

THE possibilities of cyanide manufacture cover practically the whole field where cyanogen products can be or are produced, because in one way or another alkali cyanide can be formed from almost any compound containing cyanogen. This accounts for the varied processes proposed by inventors and chemical engineers.

Cyanogen products are deserving of interest; they are on the boundary between inorganic and organic chemistry, in fact, they are on both sides of the fence, which often creates some inconvenience.

An alkali cyanide (RCN) has all the properties of an inorganic salt, like an alkali halide. yet from an organic point of view it must be considered as the nitrile of formic acid, and its chemical behavior bears it out.

For instance, if a cyanide is hydrolyzed under proper conditions we get a formate:

$$NaCN + 2H_2O = NaOOCH + NH_3$$

or if hydrogen cyanide is reduced we get methylamine

$$HCN + 2H_2 = H_3CNH_2$$

The same applies to cyanogen (C_2N_2), which is the nitrile of oxalic acid, NC.CN, ethane dinitrile.

History of Cyanogen Products

Cyanogen products hold several historical records. C_2N_2, cyanogen, was isolated in a pure state by Gay-Lussac in 1815, which is the first recorded instance of the isolation of a compound radical. Another record, which I shall refer to a little later, is the fact that the first commercial process in the world for using atmospheric nitrogen to form a chemical compound was a process for the manufacture of ferrocyanides.

By the word "cyanide" in this paper I refer to an alkali cyanide, which has reference today chiefly to sodium cyanide, potassium cyanide being met with scarcely any more in the commercial world, except as a pharmaceutical and laboratory chemical.

When cyanide first became a commercial article, it was in the form of potassium cyanide, and as the art developed mixtures of sodium cyanide and potassium cyanide became the commercial article, while today sodium cyanide of high purity is universally used.

Since the user of cyanides really only wants the cyanogen ion (-CN), it is not so important whether sodium or potassium is the carrier. Since the largest users of cyanide are located long distances from points of manufacture, the more -CN a product contains the lower the freight charge on the cyanogen bought, therefore the lower the atomic equivalent weight of the carrier of the cyanogen ion the better the consumer likes it.

Thus lithium cyanide would be a very desirable product if it could be manufactured cheaply enough, and even calcium cyanide would be better than sodium cyanide. Owing, however, to the instability of calcium cyanide, it is doubtful whether it will ever have a commercial future.

Uses of Ferrocyanides and Cyanides

Originally, ferrocyanides were manufactured to make prussian blue, which was, and still is, used as a coloring matter. Alkali cyanides became important only after the McArthur and Forest researches around 1890 showed such astonishing results in the working up of low-grade gold ores. The cyanide industry obtained an impetus and vitality at that time which made it acquire rapid development, and as its production price decreased, more and more uses for cyanide have been found, so that there is every reason to believe that the demand for cyanide will still increase. Despite the fact that the flotation process in the mines has decreased the use of cyanide, the other uses of cyanide are continually increasing, so that as far as the disposition of cyanide is concerned, its use in the mines will soon be of secondary importance.

In Fumigation and Industries

Fumigation with hydrocyanic acid has developed into a large industry, and possibly the largest consumption of cyanide must be credited to this industry. A short time ago fumigation with hydrocyanic acid was done by generating the gas where the fumigation took place, but now liquid hydrocyanic acid is used direct and there are two plants in California manufacturing the acid. The greatest use of hydrocyanic acid is for an insecticide (originally for killing the San José scale) in the orange groves, and I believe today every orange coming from California has undergone a fumigation with hydrocyanic acid. Hydrocyanic acid is perhaps the best insecticide known, and can be used for fumigating plants and foods without detriment. Buildings and vessels can be fumigated with advantageous results, in fact the United States Government has already used this process on many ships. The difficulties regarding the transportation of hydrocyanic acid, which I have no doubt will be overcome, prevent this material being more extensively used.

The electroplating industry, which also includes the metal cyanides, are also important users of cyanides. The casehardening of steel, where sodium cyanide and also ferrocyanides are used, has grown extensively with the increased production of motor vehicles and other mechanical arts. Smaller uses include submarine paint, fluxing powders for brazing and welding, organic chemicals, pharmaceutical and laboratory reagents.

Consumption of Cyanides

It is very difficult to give any exact data regarding the consumption of cyanides in this country, as the

*Paper read before the New York Section, American Electrochemical Society, Jan. 23, 1920.

Government statistics generally include other chemicals, owing to the fact that for many years there has only been one producer. Therefore, the figures given here can only be considered approximately. In 1898 the consumption in the United States was about 3,000,000 lb.

The consumption was practically trebled in the next year (1899). The consumption has continually grown, about 16,000,000 lb. per year being manufactured in the United States between 1914 and 1918, according to Government statistics, while previous to the war an additional 9,000,000 lb. per year was imported. Of course during the war very little of European goods found their way here. During 1917 about 1,500,000 lb. came here from England. There appears therefore to be a market here for about 25,000,000 lb. per year.

Commercial Cyanide Processes

Originally potassium cyanide was manufactured from ferrocyanides, by just heating the same.

$$2K_4Fe(CN)_6 = 8KCN + 2FeC_2 + 4N$$

Here was a large loss of nitrogen, and a great improvement occurred when the ferrocyanide was melted up with potassium carbonate.

$$2K_4Fe(CN)_6 + 2K_2CO_3 = 10KCN + 2KCNO + 2CO_2 + 2Fe$$

Here the finished product was contaminated with cyanate, which, however, did not offer any detriment to the extraction of gold from the ore.

Over twenty-five years ago Hamilton Y. Castner produced metallic sodium comparatively cheaply and this allowed the cost of the above process to be considerably lowered. Instead of using potash for making a melt with the ferrocyanide, sodium was used, thus giving all the nitrogen as cyanide.

$$K_4Fe(CN)_6 + 2Na = 4KCN + 2NaCN + Fe$$

Sodium or potassium ferrocyanide we will always have with us as long as the gas industry lasts. In the gas industry a large number of complex cyanogen and ferrocyanogen products are collected, which are converted to ferrocyanides. There is a good market for sodium ferrocyanide today, and the price is too high to allow it to be used as a raw material for making sodium cyanide.

Castner and Pfleger's Process

Soon after this an entirely new process for the manufacture of cyanides was developed, using Castner's metallic sodium as a basis. The process was developed by Castner and Pfleger, and is important, as it is the predominant cyanide process of today.

The process is chemically very simple:

$$2Na + NH_3 + C = 2NaCN + 3H_2$$

This reaction, however, takes place in three steps.

$$(1)\quad 2Na + 2NH_3 = 2NaNH_2 + H_2$$

$$(2)\quad 2NaNH_2 + C = Na_2CN_2 + 2H_2$$

$$(3)\quad Na_2CN_2 + C = 2NaCN$$

The process is very interesting and deserves the greatest consideration for anyone developing a new process. The commercial manufacture of cyanide by this method is very clean, and as the finished product is a melt and is cast direct into forms, very little handling is required and no loss by decomposition is endangered, as in the case where solutions are handled. It has none of the disadvantages or expenses encumbering a process where cyanide has to be separated from liquids.

The expensive raw materials are ammonia and metallic sodium. As regards ammonia, we all know that a synthetic process for making cheaper ammonia will soon be realized. Metallic sodium is made by the Castner process by electrolyzing caustic soda, and this process has been considerably improved in the last decade by Dr. H. R. Carveth and his assistants. There is also another sodium process in commercial operation in West Virginia, where sodium chloride is electrolyzed. This process was developed by R. J. McNitt. I especially bring these points out, because cyanide manufactured by this method is not burdened by any leaching or dissolving process, which in the case of cyanides is quite an expensive and unpleasant operation, and even with the higher cost of raw materials a synthetic process where the finished product has to be leached out must be very efficient to offset the higher priced raw materials in the present process.

The Schlempe Process

Another process which is worthy of mention is the so-called "Schlempe process." This process uses the residues from beet sugar manufacture (vinasse). This process has been in operation in Germany at the Dessauer Refinery since about 1900 and was developed to a commercial success by Bueb. Owing to the large distance separating the various beet sugar factories here, it has possibly been found impractical to install such a plant, because a small plant could easily use the residues from several beet sugar plants.

The vinasse consists chiefly of potash salts. The vinasse is distilled and the vapors contain ammonia and trimethylamine. This latter is passed over heated porcelain and decomposed at a temperature of 1,000 to 1,100 deg. C. into HCN.

$$N(CH_3)_3 = HCN + 2CH_4$$

The gases have to be moved rapidly, otherwise the hydrocyanic acid gas decomposes:

$$HCN + 3H_2 = NH_3 + CH_4$$

The hydrocyanic acid is absorbed by caustic soda solution and evaporated *in vacuo*, and at a temperature of 30 deg. C., cyanide separates out. The carbonized residue left in the distilling retort is leached to obtain potash salts.

Recovery of Alkali Cyanides From Aqueous Solutions

Just a word on the recovery of alkali cyanides from aqueous solutions. Owing to the easy decomposition of aqueous solutions containing alkali cyanide, many of the earlier processes failed.

The two following reactions are likely to take place where cyanides are in solution:

$$(1)\quad NaCN + H_2O = HCN + NaOH$$

$$(2)\quad NaCN + 2H_2O = NH_3 + NaCOOH$$

If cyanide solutions are contaminated with salts, other than small quantities of the hydroxide or carbonate of the alkali, recovery by crystallization is very difficult and generally impossible. Therefore it has frequently to be converted into ferrocyanide and crystallized.

When a solution is obtained by saturating a pure caustic solution with hydrocyanic acid, a little excess of caustic should always be allowed to remain. Such a solution can be evaporated *in vacuo* and cooled, when crystals of cyanide ($NaCN, 2H_2O$) will appear. These crystals are centrifuged and dried *in vacuo*, when a white loose powder of anhydrous cyanide will remain. The powder can be compressed into briquets at a pressure of about three tons to the sq.in. These treatments

require that the cyanide has to pass through several costly steps, and the longer the cyanide is in solution the greater the loss by decomposition.

New and Proposed Processes

We now come to a discussion of some of the possible new fields for the development of future cyanide processes. The future development in this direction will use atmospheric nitrogen as the basic raw material, and the processes can be divided into two main groups, namely, direct synthetic formation of cyanides and the indirect formation of cyanides.

The first group (I) is divided again into two subdivisions, (*a*) cyanides from nitrogen, alkali, and carbon, and (*b*) fixation of hydrogen, carbon (or hydrocarbons) and nitrogen in the electric arc or at high temperatures.

The second main group (II) consists of making cyanides indirectly from carbides, nitrides and combinations of these compounds.

Cyanides From Nitrogen, Alkali and Carbon

The formation of alkali cyanide by passing atmospheric nitrogen over heated alkali carbonate and carbon is very old.

Already in 1839 Lewis Thompson spoke before the British Society of Arts on making prussian blue by passing atmospheric nitrogen over carbon and potash under favorable conditions, and in 1843 Possoy and Boissierre (Br. Pat. 9,985) erected a factory near Paris to make potassium ferrocyanide by passing atmospheric nitrogen over strongly heated charcoal saturated with potassium carbonate. Owing to the excessive fuel requirements the process was moved after one year to Bramwell & Co.'s works at Newcastle, England, who were manufacturers of prussian blue. Several improvements were introduced, and cheaper fuel obtained. Iron ore was added to the charge in the retorts, and the process was in operation for two years and is reported to have manufactured one ton potassium ferrocyanide per day. The process was not a commercial success and was abandoned on account of the large amount of fuel used and the short life of the retorts.

The Possoy and Boissierre process is of great historical interest, as it is the first commercial process on record where atmospheric nitrogen was used as a raw material and entered into the reaction, and the value of iron as a catalytic agent was recognized even before the publication of Bunsen and Playfair's investigations (*Brit. Assoc. Report*, 1845, p. 185) on the formation of potassium cyanide in the blast furnace.

Many Experiments With Small Variations

Since that time a host of experimenters have taken up this subject and with small variations have endeavored to find a process for making cyanide by an inexpensive process.

In 1862 Marguerite and Sourdeval replaced the potash with barium hydrate and carbonate, which appeared to be a great step forward, as barium products, especially barium carbide, have great affinity for nitrogen and further, the barium oxide and carbonate do not fuse as easily as the corresponding alkali compounds. The nitrogen was exceedingly well absorbed, but no cyanide was manufactured, only ammonia, as steam was passed over the mass at 300 deg. C. Mond (U. S. Pat. 269,309), in 1892, tried to improve this process by mixing calcium carbonate, magnesium carbonate, strontium carbonate to the mass, with the idea of increasing the ammonia yield.

V. Adler's patents (Ger. Pat. 12,351 *et al.*), 1881-1885, are worthy of mention and show that he did quite a lot of work to accomplish commercial results, and if the engineering art had been as far advanced then as it is today he would have possibly achieved far better results.

However, many attempts have been made and much money has been spent on these efforts to manufacture cyanides from the nitrogen of the air by these methods, and a large number of patents exist for more or less improvements, but in spite of all efforts none of these methods has become commercially successful.

Even today similar processes are being developed, but as far as I know no product by these processes is yet on the market.

The Bucher Process

This method of forming cyanides has been very thoroughly brought out recently by John A. Bucher (*Amer. Inst. Chem Eng.*, 1916, p. 335). The work of Prof. Bucher has been widely quoted and his laboratory work is very creditable to him. The Bucher process is very similar in principle to the older processes and recognizes that large quantities of iron must be present to obtain satisfactory results. This process was recognized at the beginning of the war by our Government as worthy of development, and a plant was erected at Saltville, Va., to manufacture cyanide by this method. Although the plant was not put in operation during the war, the Government officials reported that the process could be considered commercially successful. However, as far as I know no material by this process has reached the market. Very similar work is being undertaken by the Air Reduction Co.

The reaction taking place is as follows:

$$Na_2CO_3 + 4C + N_2 = 2NaCN + 3CO - 138{,}500 \text{ cal.}$$

The advantage of such a process compared with the present one is the use of cheap raw materials. The most important steps in the manufacturing process are the fine grinding of iron and charcoal, impregnating the mass with sodium carbonate, making it up into uniform size pieces and very thoroughly drying the formed mass. These pieces are then introduced into a retort externally heated, and reacted on with atmospheric nitrogen at temperatures below 1,080 deg., as above that temperature the formed cyanide decomposes in the presence of iron.

$$2NaCN + Fe \text{ above } 1{,}080 \text{ deg. C.} \rightarrow FeC_2 + 2Na + N_2$$

The cyanided mass in the retort must be either allowed to cool in an atmosphere of nitrogen in the retort or else taken out of the same without allowing the heated mass to come in contact with the air, as in the latter case decomposition takes place by the burning of the cyanide and the formation of iron cyanogen compounds, which would necessitate converting the cyanide products formed into ferrocyanide. When the mass is cold the soluble cyanide and unconverted carbonate is lixiviated with water, great care being used to prevent formation of ferrocyanide. It is advisable to have a slight amount of unconverted sodium carbonate present, as this helps prevent the formation of ferrocyanide.

The further steps represent the separation of the sodium cyanide from the aqueous solution, which I have already described. Efforts have been made to use organic solvents to extract the cyanide instead of

water, which would be very desirable, but this adds to the expense.

The disadvantages offered by this process are the number of steps involved, the short life of the retorts, the inability to use the finely divided iron many times, owing to the accumulation of impurities, and the separating the sodium cyanide from aqueous solution. It will therefore be seen that the expense incurred to overcome the many disadvantages considerably offsets the advantage of using cheap raw materials. In connection with lixiviation it is practically impossible to dissolve out all the sodium cyanide from the mass, and 0.5 to 1 per cent cyanide remains undissolved. This could of course be extracted, but the time involved and the extreme diluteness of the solution obtained makes such a step uneconomical.

The R. & H. Developments

In 1894 H. Y. Castner (U. S. Pat. 239,643) described a process for the formation of sodium cyanide by passing a current of nitrogen over heated charcoal upon which the alkali metal flows. As far as I have been able to ascertain he did not conduct any experiments in this direction, expecting later to undertake the investigation which his early death prevented him from carrying out. However, during the last decade considerable work in this direction has been carried on by the Roessler & Hasslacher Chemical Co. By the direct combination of the elements sodium, charcoal and nitrogen, sodium cyanide is formed. This reaction is exothermic and on a small laboratory scale gives very efficient results.

In developing this process to a commercial scale a large number of difficulties have had to be dealt with. In this process a simple end product is desired, as in the present process where ammonia is used instead of atmospheric nitrogen, that is, the finished furnace product must be a pure melt of sodium cyanide.

The desired reaction is as follows:

$$2Na + 2C + N_2 = 2NaCN + 46{,}200 \text{ cal.}$$

If nitrogen gas and sodium vapor are passed over heated charcoal, sodium cyanide is easily formed. Even at temperatures as low as 650 deg. C., the cyanide is formed. With a rise in temperature the reaction is speeded, and if temperatures over 1,080 deg. are obtained no iron retort must be used, as otherwise the iron will decompose the formed cyanide and the retort will gradually go to pieces. Of course catalytic substances, like iron, will help speed the reaction at lower temperatures, but in that case the cyanide would have to be lixiviated, which disadvantage would easily offset any advantages over the present process, where ammonia is used.

The great difficulty experienced is not in obtaining a suitable material for a retort, but in separating the formed sodium cyanide from the charcoal. Although sodium cyanide melts below 600 deg. C., it is held fast by the charcoal, in which it is absorbed, and surrounds the particles of charcoal so that sodium vapor and nitrogen cannot come in contact with it. Of course a large amount of formed cyanide will drip off the charcoal mass, but a cyanided mass will by degrees fill the retort.

The alternative of this difficulty is to distill off the formed cyanide, which is feasible, as there are no other substances present which could distill over. In the case where sodium carbonate or chloride is present it is not easy to distill the cyanide, as both these salts are more volatile than sodium cyanide. Sodium cyanide can be heated to a high temperature without decomposing. Temperatures of 1,250 to 1,300 deg. C., about which temperatures sodium cyanide distills, do not decompose it. Sodium cyanide can be volatilized at a much lower temperature in a current of nitrogen gas.

The process consists of feeding finely divided charcoal into a retort or electric furnace, which must be heated initially to start the reaction. This reaction, being exothermic, can be self-sustaining. Sodium vapor can be produced inside of the furnace or else conducted from the outside into the carbon mass. The nitrogen of course must be led from the outside. The finished product, which is distilled off, can be melted again and cast into forms or can be used as taken from the condensers.

The advantages such a process would show are an exothermic reaction, continuous operation of furnace, little or no expense on finished furnace product, and few steps in the operation.

The disadvantages are the high cost of one of the raw materials, namely, metallic sodium. I do not think sodium cyanide from such a process is regularly reaching the market, although quite a quantity in the past has been produced. The process is not yet far enough advanced to be considered a commercial success.

Fixation in the Electric Arc

The commercial development of making hydrocyanic acid gas at high temperature was started only shortly before the war, although laboratory experiments date back to the latter part of last century.

The electric-arc furnaces have for their object the synthesizing of hydrogen and carbon (or a hydrocarbon) with atmospheric nitrogen. Much of the experience gained by the work done to combine the nitrogen and oxygen in the arc has considerably helped the development of such processes, although as early as 1879 James Dewar showed that gaseous mixtures containing nitrogen and hydrogen passed over heated carbon formed hydrocyanic acid.

Whether hydrocyanic acid or cyanogen is formed synthetically is not of such great moment, as they can both be converted into cyanides by absorbing them over or through a fused alkali or solution of alkali hydrate, although hydrocyanic acid is the most desired product. Dewar considered the temperature of the electric arc was necessary to combine these elements; Smith and Hutton of the University of Manchester showed by laboratory experiments that hydrogen and nitrogen in contact with carbon at temperatures above 1,800 deg. C. produced hydrocyanic acid to a very marked extent, the formation of hydrocyanic acid increasing rapidly with the increase of temperature.

The Lipinski Process

The work of A. V. Lipinski (*Z. Elektrochem.*, vol. 17, p. 761) is certainly deserving of interest. He investigated the formation of hydrocyanic acid by reacting methane and nitrogen in the high potential arc, and just previous to the war this process was developed to a commercial scale at Neuhausen, Switzerland. The process was in 1914 declared to be working well, and the trouble which had been originally experienced by carbon depositing on the electrodes was reported to have been overcome. It is reported that the methane was completely converted into hydrocyanic acid according to the following equation:

$$2CH_4 + N_2 = 2HCN + 3H_2$$

The use of hydrocarbon of course overcomes the use of hydrogen as a raw material. However, Lipinski obtained the best results by using a mixture consisting of 13 to 24 per cent nitrogen, 5 to 10 per cent methane, 66 to 81 per cent hydrogen. It was reported that 30 g. HCN per kw.-hr. were obtained.

To overcome the use of hydrogen as a raw material experiments were conducted to use richer hydrocarbons, which of course would increase the possibility of carbon deposits on the electrodes and other parts of the apparatus. This is one of the great objections in all high-temperature processes where hydrocarbons are used. The carbon deposited at high temperatures is extremely dense and seems to be of a graphitic nature, and it packs so hard that it is often extremely difficult to remove. This is corroborated by looking over the patent literature, where one will note the suggestions made to obviate carbon deposits. Whether Lipinski's process has continued to prove commercially successful I am unable to say, as no news regarding it has reached this country during the last four or five years.

The use of catalyzers and contact substances to reduce the reaction temperature has also received considerable attention; in fact, Lipinski used metallic vapors in his arc and also vapors of salts, like calcium chloride. P. A. Starke (U. S. Pat. 1,306,862) considerably lowers the temperature of synthetically combining hydrogen, nitrogen and hydrocarbon by passing the same over catalytic masses containing iron, nickel and cobalt, together with an earth alkali oxide, but offers no figures as to results obtained. His work is possibly still in an experimental stage and no doubt considerable difficulties have to be overcome to make such a process commercial. Starke uses no arc, but claims temperatures between 800 and 1,000 deg. C.

It is very probable that quite a lot of work has been done with arc furnaces for making cyanides and hydrocyanic acid of which little has been published. This field offers certainly a possible solution for the formation of cheaper cyanides.

If results of 30 g. HCN can be obtained per kw.-hr., such a process would prove very valuable for making cheap cyanides. Even with power at $20 or over per kw.-yr., a large margin is left for the working up of the cyanide solutions. Experiments in working out such developments are possibly no more expensive than the cost of developing some of the processes now being experimented with, and this field holds out one of the hopeful ways to the future production of cheap cyanides.

Cyanides From Carbides, Nitrides and Combinations of These Compounds

In making cyanide indirectly from other products containing combined nitrogen, fixed from atmospheric nitrogen, work has chiefly concentrated on converting the atmosperic nitrogen, combined to calcium carbide, in calcium cyanamide into sodium cyanide.

The manufacture of cheap cyanide from cyanamide is now an accomplished thing and has been developed in this country. As soon as the impetus was given to the cyanide industry, Frank and Caro in 1895 studied the possibility of absorbing nitrogen by passing the same over heated carbide. The affinity of barium compounds for nitrogen had already been recognized, and this perhaps explains why the experiments were started with barium carbide. Nitrogen gas is absorbed easily by barium carbide at comparatively low temperatures, but the resulting product consists of a mixture of barium cyanide and barium cyanamide, $Ba(CN)_2$ + $BaCN_2$, this material, according to G. Erlwein (1903, Fifth Inter. Cong. of Appl. Chem., vol. 1, p. 646) if used with sodium carbonate and carbon converts all the nitrogen into cyanide. By this method sixth-sevenths of the nitrogen absorbed could be recovered as sodium cyanide. The idea was to convert the barium residues again into carbide and use it over and over again, but owing to the impurities remaining in the carbide and continually increasing, the reaction product had to be discarded after a few operations. This method proved too costly and the process was abandoned. The experiments were continued, using calcium carbide as the reaction material, and in this case no cyanide was formed, the product being calcium cyanamide, $CaCN_2$. Erlwein and Frank tried to convert this material into cyanide by fusing it with sodium chloride, but only traces of cyanide were formed.

The following reaction is supposed to take place by fusing calcium cyanamide with sodium chloride:

$$CaCN_2 + 2NaCl \leftrightharpoons CaCl_2 + Na_2CN_2$$

As commercial calcium cyanamide already contains carbon, it was expected that the following reaction would take place:

$$Na_2CN_2 + C = 2NaCN$$

but this reaction did not take place and no results were obtained. It was then suggested by Freudenberg of Frankfort to use the calcium cyanamide material in the fertilizing industry.

Commercial Process Developed by Dr. Landis and His Staff

P. Kruger (Ger. Pat. 246,064) stated in 1910 that charcoal must be added to the calcium cyanamide-sodium chloride fusion to convert the cyanamide nitrogen into cyanide. It remained, however, for Dr. Landis and his staff to develop a commercial process in this direction.[1] It is true the product is only a low per cent sodium cyanide-containing mass (35 per cent NaCN), yet it is finding extensive use. It is very probable that experiments are being conducted to obtain a higher percentage product. It will not be an easy matter to distill off the cyanide, as the other salts present in the mass wou'd volatilize with the sodium cyanide.

The advantages of such a process are cheap raw materials, and the disadvantages are the large number of steps in the process, the fact that the furnace must operate intermittently and the low per cent product obtained.

Another field open for investigation lies in the formation of certain metallic nitrides or carbonitrides. It is well known that several elements, like titanium, magnesium, aluminum, etc., form combinations with nitrogen and carbon. It appears that small experiments along these lines have been conducted; but nothing of any definiteness has yet been published which offers anything that could be construed as conducive to allow immediate hope for any development here to produce cheap cyanides. The field is still wide open and a lot of scientific investigation must preface such work, to study conditions of formation of nitrides and carbonitrides, their properties and possibilities of converting the combined nitrogen into a cyanide-containing material.

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New Brunswick, N. J.

[1] See W. S. Landis, "A New Cyanide," Chem. & Met. Eng., vol. 22, No. 6, Feb. 11, 1920, pp. 265-268.

Tests on Small Engines at High Back Pressures

By Alan E. Flowers, R. J. Pepper and Crosby Field

CALCULATIONS based on theoretical considerations covering a wide range of probable operating conditions such as it would be necessary to make in an attempt to get full rated output when employing high back pressures are given by one of the authors in Chemical & Metallurgical Engineering, Jan. 1, 1919, page 18, vol. 20. Results of tests on small steam-driven compressors operating under conditions different from those given therein, and yet which are frequently found in chemical plants, indicate that the curves may be applied as an approximate method of calculation to these conditions. The increase in steam consumption with an increase in back pressure from

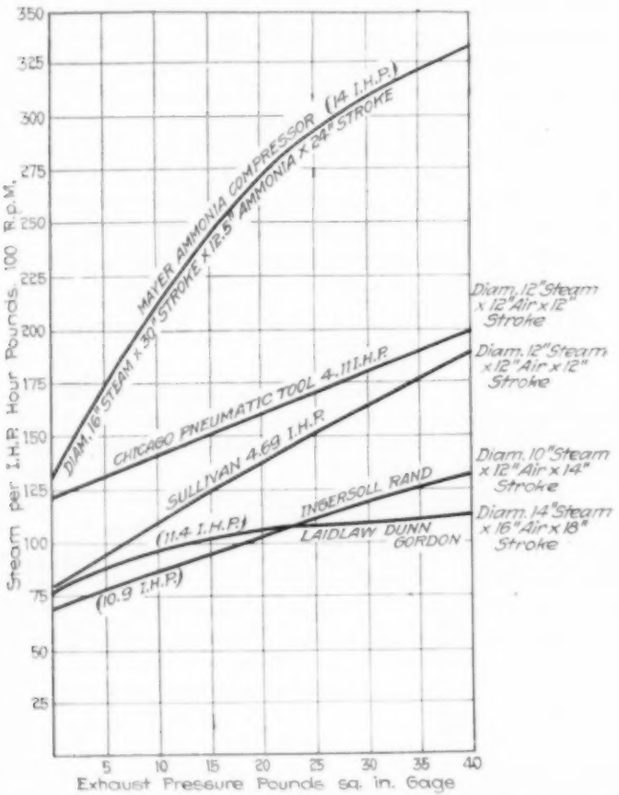

Steam per I.H.P. Hour Pounds, 100 R.p.M.
Exhaust Pressure Pounds sq. in. Gage
MAYER AMMONIA COMPRESSOR (14. I.H.P.)
DIAM. 16" STEAM x 30" STROKE x 12.5" AMMONIA x 24" STROKE
CHICAGO PNEUMATIC TOOL 4-11 I.H.P.
SULLIVAN 4.69 I.H.P.
(11.4 I.H.P.)
INGERSOLL RAND
LAIDLAW DUNN GORDON
(10.9 I.H.P.)
Diam. 12" Steam x 12" Air x 12" Stroke
Diam. 12" Steam x 12" Air x 12" Stroke
Diam. 10" Steam x 12" Air x 14" Stroke
Diam. 14" Steam x 16" Air x 18" Stroke

FIG. 1. EFFECT OF BACK PRESSURE ON TOTAL STEAM CONSUMPTION AT CONSTANT NO LOAD

atmospheric to 40-lb. gage in five widely different types of machines varied from 33 per cent to 58 per cent, with an average of 49 per cent. The governors operated on the throttling principle with cut-off constant, but all varied in design, and the quality of the steam varied, whereas the curves in former articles were based on either boiler steam pressure adjustment or variable cut-off and saturated steam. Nevertheless the figure for the increase in steam consumption on the curve most nearly applicable to these conditions was 50 per cent, which compares favorably with the 49 per cent average value found. The actual results found are given in the curves herewith.

The units varied from 12.3 to 80.5 indicated hp. per 100 r.p.m. at full load, the average inlet steam pressure was 120-lb. gage, the average quality of the live steam was 99.2 per cent, while that of the exhaust steam was between 87 and 90 per cent.

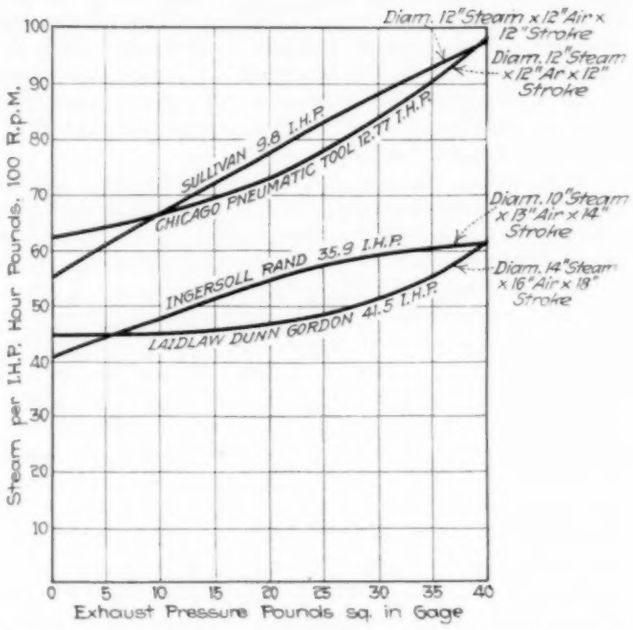

Steam per I.H.P. Hour Pounds, 100 R.p.M.
Exhaust Pressure Pounds sq. in. Gage
Diam. 12" Steam x 12" Air x 12" Stroke
Diam. 12" Steam x 12" Air x 12" Stroke
SULLIVAN 9.8 I.H.P.
CHICAGO PNEUMATIC TOOL 12.77 I.H.P.
Diam. 10" Steam x 13" Air x 14" Stroke
INGERSOLL RAND 35.9 I.H.P.
Diam. 14" Steam x 16" Air x 18" Stroke
LAIDLAW DUNN GORDON 41.5 I.H.P.

FIG. 2. EFFECT OF BACK PRESSURE ON TOTAL STEAM CONSUMPTION AT CONSTANT HALF LOAD

TOTAL STEAM CONSUMPTION—FULL LOAD

Name of Compressor	I.hp. per 100 r.p.m.	Total Steam Consumption at Atmospheric Pressure and 100 r.p.m.	Total Steam Consumption at 40 Lb. Back Pressure and 100 r.p.m.
Ingersoll-Rand	51.9	2,025	2,690
Sullivan	12.3	685	1,087
Chicago Pneumatic	18.1	930	1,410
Laidlaw-Dunn-Gordon	59.7	2,150	3,140
Mayer	80.5	5,360	8,440

RATE OF STEAM CONSUMPTION

Name of Compressor	Steam per i.hp. at Atmospheric Pressure	Steam per i.hp. at 40-Lb. Back Pressure	Increase in Per Cent
Ingersoll-Rand (air)	39	51.8	33
Sullivan (air)	56	88.5	58
Chicago Pneumatic (air)	51.5	78	52
Laidlaw-Dunn-Gordon (air)	36	52.5	46
Mayer (ammonia)	66.5	105	58

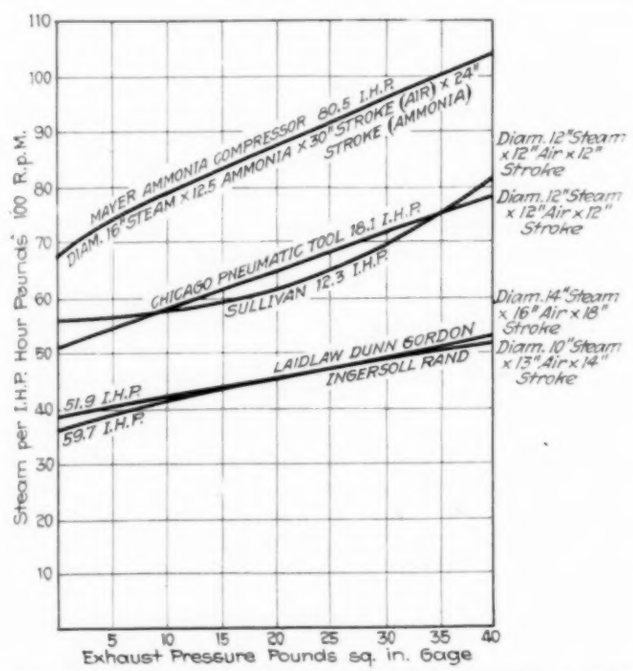

Steam per I.H.P. Hour Pounds, 100 R.p.M.
Exhaust Pressure Pounds sq. in. Gage
MAYER AMMONIA COMPRESSOR 80.5 I.H.P.
DIAM. 16" STEAM x 12.5 AMMONIA x 30" STROKE (AIR) x 24" STROKE (AMMONIA)
CHICAGO PNEUMATIC TOOL 18.1 I.H.P.
SULLIVAN 12.3 I.H.P.
LAIDLAW DUNN GORDON
INGERSOLL RAND
51.9 I.H.P.
59.7 I.H.P.
Diam. 12" Steam x 12" Air x 12" Stroke
Diam. 12" Steam x 12" Air x 12" Stroke
Diam. 14" Steam x 16" Air x 18" Stroke
Diam. 10" Steam x 13" Air x 14" Stroke

FIG. 3. EFFECT OF BACK PRESSURE ON TOTAL STEAM CONSUMPTION AT CONSTANT FULL LOAD

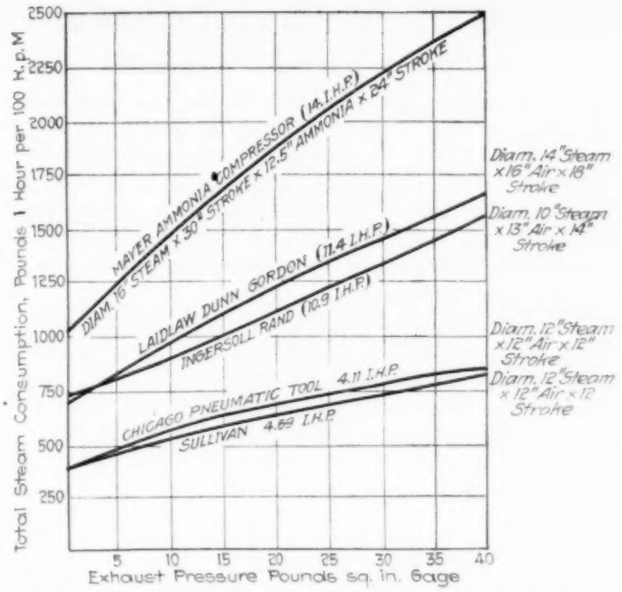

Total Steam Consumption, Pounds 1 Hour per 100 H.p.M
2500
2250
2000
1750
1500
1250
1000
750
500
250
MAYER AMMONIA COMPRESSOR (14 I.H.P.)
DIAM. 16" STEAM x 30" STROKE x 12.5" AMMONIA x 24" STROKE
LAIDLAW DUNN GORDON (11.4 I.H.P.)
INGERSOLL RAND (10.9 I.H.P.)
CHICAGO PNEUMATIC TOOL 4.11 I.H.P.
SULLIVAN 4.69 I.H.P.
Diam. 14" Steam x 16" Air x 18" Stroke
Diam. 10" Steam x 13" Air x 14" Stroke
Diam. 12" Steam x 12" Air x 12" Stroke
Diam. 12" Steam x 12" Air x 12 Stroke
5 10 15 20 25 30 35 40
Exhaust Pressure Pounds sq. in. Gage

FIG. 4. EFFECT OF BACK PRESSURE ON TOTAL STEAM CONSUMPTION AT CONSTANT NO LOAD

The equipment tested consisted of steam-driven air and ammonia compressors of several different makes and ratings. These units were operated exactly as they had been in normal plant operation except that the exhaust pressure was regulated and held constant at the three chosen values of 5, 20 and 40-lb. gage and the load held constant. Normal power plant units operate in actual service at 40-lb. gage back pressure, and these units have been successfully giving the service demanded of them during several years of operation. Air compressor units are equipped with fly ball type throttling governors, the output remaining fixed. One unit had its governor equipped to be controlled by the pressure of air in the compressed air system.

During the tests the air pressure was controlled by a valve manipulated by an observer stationed at a gage on the compressed air system.

During normal operation, the back pressure was governed by the demand for steam in the 40-lb. steam pressure system, additional steam being supplied when needed for the chemical processes either through an automatically operated reducing valve admitting live steam at 125-lb. pressure to the 40-lb. system or by manually operated valves. On the other hand, when the power demands were such that the exhaust steam of the power units was in excess of the immediate demands of the chemical processes, the plant operator discharged the excess into a hot well, where its heat energy was conserved in warming water. Any desired degree of closeness of control can be obtained by these means.

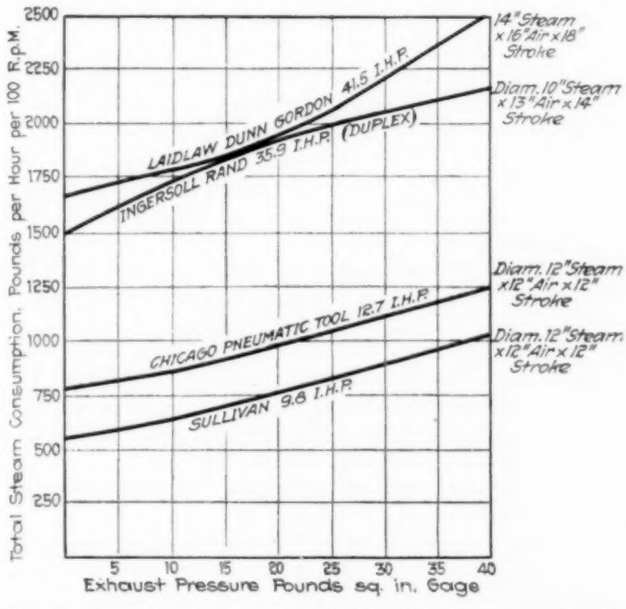

Total Steam Consumption, Pounds per Hour per 100 R.P.M.
2500
2250
2000
1750
1500
1250
1000
750
500
250
LAIDLAW DUNN GORDON 41.5 I.H.P.
INGERSOLL RAND 35.9 I.H.P. (DUPLEX)
CHICAGO PNEUMATIC TOOL 12.7 I.H.P.
SULLIVAN 9.8 I.H.P.
14" Steam x 16" Air x 18" Stroke
Diam. 10" Steam x 13" Air x 14" Stroke
Diam. 12" Steam x 12" Air x 12" Stroke
Diam. 12" Steam x 12" Air x 12" Stroke
5 10 15 20 25 30 35 40
Exhaust Pressure Pounds sq. in. Gage

FIG. 5. EFFECT OF BACK PRESSURE ON TOTAL STEAM CONSUMPTION AT CONSTANT HALF LOAD

No heat reservoir was used in connection with this 40-lb. steam system other than that afforded by the volume of the pipe mains. Reservoirs filled with hot water at the temperature of average steam pressure have been used in connection with low-pressure exhaust steam-driven turbo units, and the use of some such

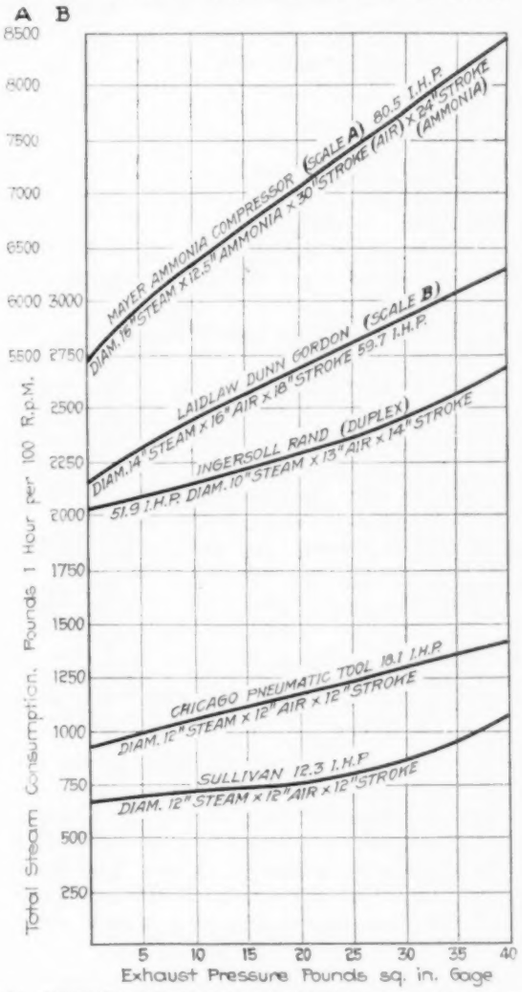


FIG. 6. EFFECT OF BACK PRESSURE ON TOTAL STEAM CONSUMPTION AT CONSTANT FULL LOAD

reservoirs should be given serious consideration in any future installation. It should also be noted that moist steam, where the moisture is scattered throughout the distribution system, must act in a similar way in providing heat storage and consequent re-evaporation when needed even more effectively than a tank, because of the greater amount of evaporating surface available, provided the condensate be not completely removed from the system as fast as formed, but remains to some extent along the bottom of the steam mains or, still better, distributed in fine particles through the body of the steam.

The Mayer ammonia compressor was equipped and

regularly operated with a fly ball governor acting through Corliss valve gear actuating an adjustable cut-off. This is the only unit tested equipped with a variable cut-off governor. During the test this unit was controlled in the same manner as the rest by throttling the steam. (One full load run on the Mayer ammonia compressor unit was made with the adjustable cut-off governor in action, resulting in a steam consumption about one-half that obtained with the throttle control.)

The general dimensions and data of the units tested are as follows:

Name of Unit	Steam Cylinder Diameter, Inches	Air Cylinder Diameter, Inches	Stroke, Inches	Piston Rod Diam., Inches	Steam Pipe Diam., Inches	I. hp. per 100 r.p.m.	Air Cyl. Displacement in Cu.ft. per 100 r.p.m.
Ingersoll-Rand	*10	13	14	1¼	3	51.9	215.5
Sullivan	12	12	12	1¼	3	12.3	155.6
Chicago Pneumatic	12	12	12	2	3	18.1	155.6
Laidlaw-Dunn-Gordon	14	16	18	2½	4	59.7	468.0
Mayer	16	..	30	2 15/16	6	80.5	....
(Ammonia)	..	12.5	24	2 15/16	..	....	340.0

* Duplex.

Operating speeds were usually from about 100 to 150 r.p.m. for the air compressors and about 35 r.p.m. for the Mayer ammonia compressor.

Steam was obtained from boilers that were supplying the entire plant, and the pressure varied somewhat during the tests, the amount of variation being determined by the usual works operating conditions. The average of the values for the steam pressure was used in working up the test results. It should be borne in mind that the load and exhaust steam pressures were closely observed and held constant, so that necessarily the same weight of steam was taken into the steam cylinder at each stroke regardless of the slightly variable boiler pressure. The only effect of a change in boiler pressure would be a corresponding change of speed. The test results have, therefore, been reduced to a common constant speed and may be truly said to represent the steam consumption for the pressures recorded. This conclusion with regard to steam consumption derived from theoretical considerations, as stated above, has also been checked and confirmed by plotting a number of the individual test values obtained at different boiler pressures and corresponding speeds. All the test results are based upon the carefully checked weights of condensed steam. The scale accuracy was checked with standard weights before the tests were begun. The weight readings were checked throughout the course of each run by keeping the scale beam floating constantly and recording the values at each 6-min. interval and comparing these with the total.

A totalizing revolution counter was used and readings were taken in three different ways. First, the speed was noted for 1 min. following each 6-min. interval, i. e., the difference between totalizing counter reading at beginning and end of each seventh minute. Second, the difference in totalizing counter readings at the beginning and end of each 6-min. interval was obtained. Lastly the total revolutions during the test were obtained as difference between readings at start and finish. The readings for 1-min. intervals were used only for check and the values used in working up the test results were the average obtained from the total reading for each run.

Before the beginning of the test, the condenser was tested for tightness of joints, and for leakage with 40-lb. pressure. Indicator cards were taken at each 6-min. interval and the indicated horsepower calculated from cards.

Surface Versus Bunsen Combustion in Gas-Fired Furnaces

IN AN address made recently to the Gas Engineering section of the Western Society of Engineers at Chicago, Prof. O. L. Kowalke, of Wisconsin University, outlined some experiments he had made in co-operation with the members of the Wisconsin Gas Association to determine the relative efficiency of the ordinary bunsen combustion as practiced in most gas-fired furnaces and the so-called surface combustion.

The problem was to determine what temperature could be attained using the gas-air mixture in each type of furnace and the relative ease with which given temperatures might be maintained. It was also desirable to discover how much oxidation would occur on the metal in the furnace when the atmosphere was either oxidizing or reducing, and the extent of structural change in the metal when heated to fairly high temperatures in strong reducing atmosphere.

Experiments were conducted in an American Gas Furnace Co. No. 5 gas furnace, 15 in. wide, 12 in. high and 18 in. long with ¾-in. gas inlet and 1-in. air inlet pipes. The muffle was removed to simulate conditions found in an ordinary heat-treating furnace. Quartz to pass ½-in. mesh was laid on the floor of the furnace with an angle of slope of 35 deg. A carborundum brick was introduced to serve as an object at which to look with the optical pyrometer.

Various mixers of gas and air were tried, the regular American Gas Furnace mixer, and the McKee mixer being principally employed. Great care is exercised by the manufacturers in constructing these mixers.

The gas was used at a 4- to 6-in. water column pressure and the air at about 5 in. of mercury, or say 2½ lb. A small blower produced the air pressure, while the gas was supplied from the commercial mains. This latter was carbureted water gas with an average B.t.u. of 600, and metered separately to the furnace.

Temperatures Reached

The furnace operating for 3 hr. without quartz bed and with unregulated supply of gas and air reached a maximum temperature of 1,420 deg. C. During this time 990 cu.ft. of gas was consumed. With the bunsen combustion, i.e., where the blast of air aspirates in the supply of gas driving the mixture to mouth of the burner, it was also hard to get high temperature in a short time.

The quartz was introduced to give surface combustion and the air was carefully regulated with an American mixer to give an excess of oxygen of about 0.1 per cent on the average and no carbon monoxide. With a gas consumption of 745 cu.ft. in 2 hr. and 36 min. a temperature of 1,420 deg. C. was obtained.

The McKee mixer was then tested, using bunsen combustion and removing quartz. The air supply was regulated to no CO and about 0.1 per cent oxygen in excess. In 1 hr. and 6 min. with 975 cu.ft. of gas the maximum temperature of 1,591 deg. C. was attained. The fireclay lining began to melt at this temperature and the furnace was shut down.

In the next test the quartz was placed in the furnace, and still using the McKee mixer, in 1 hr. 56 min. the temperature reached 1,700 deg. C. The quartz in front of the orifices melted down. One thousand cu.ft. of gas was consumed.

These experiments seemed to demonstrate that the intimacy of mixtures of air and gas, with a careful regulation of the air supply, is a factor of great importance, and it is a question which may be debated as to whether it is not fully as important as the impingement of the gas on an incandescent surface. In support of this an experiment made several years ago with producer gas giving about 145 B.t.u. per cu.ft. with a certain mixing device produced a temperature of 1,425 deg. C.

Maintaining Temperature

A series of experiments was made in which the temperature was raised to about 900 deg. C. so that an optical pyrometer of the disappearing filament type could be used. This insured certainty of calibration of pyrometer remaining constant.

With the ordinary bunsen combustion and old style mixer a temperature from 985 to 995 deg. C. consumed 125 cu.ft. of gas in 1 hr.

The same mixer and furnace, but with the quartz introduced to give surface combustion, maintained a temperature of 988 to 994 deg. C. for 1 hr., with a gas consumption of 109 cu.ft., or a saving of 16 cu.ft. over the former method.

The test with the McKee mixer, venturi type, used 105 cu.ft. of gas per hr. in maintaining the furnace at a temperature of 883 deg. C.

Oxidation of Metal

Specimens of 0.95 per cent carbon steel, ½ in. diameter, 2 in. long, with flat spots for making measurements, were left in furnace for various periods of time, removed, quenched in water, oxide film just removed and calipered.

In from 5 to 15 min. heat with a 19 per cent carbon monoxide mixture the diameter reduction was 0.0003 in. With a 1 per cent carbon monoxide mixture the loss was about the same. With 0.4 per cent oxygen the loss was slightly increased, and with 1.3 per cent of oxygen the loss in diameter was doubled.

It was found that in a 4 per cent atmosphere of carbon monoxide, acting on 0.95 carbon steel over a period of an hour and a half the specimen was severely decarbonized and the product was practically soft iron.

Woodine

"Woodine" is the new name for wood alcohol which has been suggested by manufacturing chemists in communications to the Commissioner of Internal Revenue. The Commissioner is drafting a bill to govern the manufacture and sale and to safeguard the use of wood alcohol. The chemists suggest that the presence of the word alcohol in the name carries with it the suggestion that it can be substituted for ethyl alcohol. It is also suggested that all wood alcohol be required to carry a label on which appears the words "A poisonous compound."

Secret of German Success in Chemical Works

In a report lately made in Glasgow by D. A. Bost on a visit to the Rhineland chemical works, he attributes the success of German chemical industries to cheap raw materials, cheap power, cheap carriage, discipline among process workers, the business capacity of the chemists, co-operation of chemists and engineers, and the willingness of the manufacturer to spend money because he had faith in the ultimate results.

Legal Notes

By Wellington Gustin

Liability of Stockholders—License to Make and Sell Patented Article Construed

A CASE involving some interesting points of law was recently decided in the Court of Appeals of New York. Here the defendant was sued as a holder of capital stock, not fully paid, by a creditor of the Tear Off Bottle Seal Co., under section 56 of the Stock Corporation Law of New York, which provides as follows:

"Every holder of capital stock not fully paid, in any stock corporation, shall be personally liable to its creditors, to an amount equal to the amount unpaid on the stock held by him, for debts of the corporation contracted while such stock was held by him." (Bottlers' Seal Co. vs. Rainey, 122 N. E., 200.)

It was alleged in the complaint that the debt of the corporation which plaintiff is seeking to enforce arose from the following facts. In December, 1909, the plaintiff granted to one Horner the sole right and license to manufacture, use and sell certain patented bottle caps for a period extending from date of the agreement to July 1, 1913, and in consideration for the granting of such license and patent rights, Horner agreed to pay plaintiff a license fee or royalty on all bottle caps and seals sold, further agreeing to pay and guaranteeing specified minimum sums each year should the aggregate royalties fall below these sums.

After making this agreement and on or about Dec. 29, 1909, Horner, with the consent of plaintiff, transferred all his interest in the agreement to the Tear Off Bottle Seal Co., which assumed and agreed to perform all its terms as agreed by Horner. It failed to perform, however, by failing to pay the amounts agreed upon when they became due. The defendant in this suit became a holder of stock not fully paid on Jan. 10, 1910. His contention is that the debt was contracted on Dec. 28, 1909, when the assignment was made. The plaintiff contended that upon the assignment of the agreement a contingent liability was incurred which ripened into a debt only as bottle caps and seals were manufactured, sold, and the payments fell due.

When Stockholders Must Pay

Said the court, the proper definition of the term "debt contracted," under the statute above quoted, is to be sought in the legislative intent to enforce the obligation to pay for stock which is assumed by one who becomes a stockholder. Under such statutes courts generally hold that a sum payable upon a contingency is not presently a debt and does not become a debt until the contingency has happened. Such decisions have had the result of relieving from liability those who were directors when the agreement creating the liability was signed, because it is said their cases were not fairly within the language of the statute. The same rule of construction must be applied to impress liability as is applied to avoid it.

The court held that the agreement transferred no more than a mere license, giving the right to make, use and sell the patented article for a period less than the full term of the patent. Properly speaking, the transaction was not an assignment of patent. The payments to be made under the contract were for the right to manufacture and sell free from interference for in-

fringement of patent. An agreement to pay such royalties is contingent and creates no debt until the time stipulated for payment arrives, said the court. Because in the meantime before the obligation to pay matures, the rights of the licensee may be lost by the interference of the licensor, or by assertion of a paramount right by a third party, or the license may be abandoned or assigned, with the consent of the licensor, or under conditions terminating the obligation to pay royalties.

When Duty to Pay Royalty Ceases

Nevertheless, as to the minimum payments, as fixed in the license agreement, it was urged the full liability of the corporation was fixed when the assignment was made and that as to such amounts the debt was then contracted. But, said the court, the promise to make such payments is not absolute. In legal contemplation, the enjoyment of the undisturbed use of the patent, not the mere execution of the grant of patent right, is the consideration for the royalties. The debt is not "contracted" until the consideration is furnished. If the right to make, use and sell the patent terminates meanwhile, if the licensor does not respect the right, if it had no right to transfer, then the duty to pay royalties ceases, the time for payment never arrives, and the debt is not contracted.

The debt is not "contracted" until it becomes a fixed liability, absolutely owing, established under the terms of the contract. Citing analogous cases for the rule of law, the court said that when a lease is signed, calling for fixed payment of rent, no debt is contracted until the premises are used or the rent becomes due. Hence the judgment against the stockholder was reversed.

Judgment to Deliver in Writing Unwritten Secret Formulas Is Impossible of Enforcement

From California comes a case dealing with the sale of secret formulas and showing why it is impossible to compel a seller to perform his agreement to deliver his secret formulas in writing. The Supreme Court of that state lays down the correct rules in transactions of this kind (Berry vs. Moulie, 179 Pac., 686).

It appears from the facts that plaintiff and defendant entered into an agreement by which the plaintiff was to purchase from the defendant his business as a manufacturing chemist and his secret formulas for manufacturing his products. This contract was partly carried out, and the business was moved from Florida to California and there established. A year later, difficulties having arisen between the parties, they entered into the contract dated June 30, 1915, which was the basis of this action, for the purpose of settling such differences. This latter contract plaintiff sought to have enforced by a decree of specific performance. Upon trial, findings and judgment were entered in favor of the plaintiff. However, later, this judgment was changed by the court after changing its conclusions of law, upon motion of the defendant. From the new judgment plaintiff appealed.

Courts Will Not Order a Performance It Cannot Enforce

On the appeal the court went into the merits of the contract to show why it would be impossible to enforce a specific performance of such contract. Now it must be understood the courts will not order a performance which it cannot enforce. By this contract the defendant transferred all the property described in the first agreement, dated June 17, 1914, and agreed in addition thereto, upon payment of a certain sum of money, "to immediately deliver possession of all and singular the formulas, recipes, and prescriptions in writing for the manufacture" of the products referred to in said contract of June 17, 1914, and the party of the second part (the plaintiff) thereupon agreed to assume the control, ownership, and management thereof, and to carry on and conduct the business, and to employ the party of the first part (the defendant) as manufacturer of the products on a certain specified salary, such employment to continue until the payments provided to be made by the second party were fully paid.

Plaintiff further agreed that he would use every effort to make the business profitable and successful, and that he would carry the trade marks and name of the seller on all the products, and that in the event that the business be sold one of the conditions of such sale should be the perpetuation, in the business so sold, of the original firm name and every trade mark adopted by it.

Findings of the Court

The court found as a fact "that defendant did not on the 30th day of June, 1915, have, nor has he since had, any written formulas, recipes, or directions for the manufacture of the products mentioned in the written agreement, but that defendant is able to reduce the same to writing, but he would, in order to reduce same to writing, be required to perform personal services and exercise his individual skill for a period of three weeks." The court also found that plaintiff was willing to employ the defendant, but that the defendant refused to perform any service whatsoever for the plaintiff.

Said the Supreme Court, the difficulty of enforcing such a contract specifically is well illustrated by the first judgment entered in the case, wherein it was decreed that the defendant should "write out or cause to be written out and authenticated when so written out" the formulas and recipes referred to in the contract and deliver the same to the plaintiff within 30 days. It was provided that upon writing out such formulas defendant was to receive $1,622, but in the event that he did not do so the plaintiff should be released from this payment. The defendant was also enjoined from engaging in the business of manufacturing such products within the State of California for the period of five years.

Agreement Not Sufficiently Certain

That portion of the decree which sought to compel the defendant to deliver or write out secret formulas is impossible of enforcement, said the court. The agreement to deliver such formulas was "an agreement, the terms of which are not sufficiently certain to make the precise act which is to be done clearly ascertainable." The contract itself was uncertain as to the secret formulas, and apparently the evidence was equally so. The secrets remained within the breast of the defendant, and he alone would know whether or not he had complied with the judgment which required him to deliver the formulas. Again the agreement specifically provided for the employment of the defendant. This agreement "to employ another in personal service" could not be specifically enforced by the defendant. That being true, said the court, there was no such mutuality of remedy between the parties as would permit specific performance.

The Personal Element in a Safety Program for the Foundry*

By M. F. Gartland

WE STATE a fact and we don't need to prove it when we say that the foundry can never be made as safe as a parlor. We may have the most expensive and most modern machinery and equipment that money can buy, our buildings may be models of perfection so far as light and ventilation and general arrangement are concerned, we may coerce our men in the matter of wearing molders' shoes, leggings, and goggles, but the fact remains that a splash of hot iron will still cause a burn when it comes into contact with the human body. A casting or a piece of pig iron will still mash a foot or break a toe if it drops at the right spot at the right time.

Our high-grade equipment will do a great deal to eliminate the splashes and other accidents due to machinery, but beyond that there is yet another element. Improved methods of handling the product will eliminate a great deal of the danger that arises from this source, but no piece of machinery or equipment has ever been made that is entirely fool-proof. We must seek yet further for the final analysis of our safety problem. We shall still have our accidents in spite of all these good things.

Elements of Danger in a Foundry

If we could operate a foundry by machinery from the pig iron yard to the shipping platform without the touch of a human hand, we should have no foundry accidents. But we can't do that; we must have men. Our foundries must be alive with men through every part of every working day. Again, if we had the men of our foundries engaged in the task of making mud pies by hand, we should have no foundry accidents. The element of danger that lies in the nature of our product would be eliminated. But we are not in the mud pie business and we are not making and shipping castings by machinery. We are making our product from pig iron and scrap. To put it on the market we must have men. Men must unload the iron, the coal, and the sand. Men must charge the furnaces and heave in the coal to heat them. Other men must draw off the molten charge and pour it into the molds, and still other men must dump the castings from the molds and follow them step by step through the finishing processes and then put them on board the cars for their destination. In each of these operations from beginning to end there is a certain element of danger from the very nature of the materials and because of the fact that human hands must direct each one of them. This element of danger or hazard can be lessened but never eliminated entirely by the installation and use of more modern equipment.

The Human Element

We are asked to discuss today the strides that have been made in the progress of safety work for foundries. Perhaps the greatest stride possible has been made when we recognize the true nature of our problem and put our hands to the task of its solution. We may say with confidence that the foundries of the country have recognized the problem and that they have set about solving it. We may find conclusive evidence of this fact in every new safety device that is installed and in every piece of so-called welfare work that is being undertaken for the workers in our plants. Owners and managers everywhere are beginning to recognize the human element that enters into their safety problem and they are all striking out, some of them blindly, perhaps, to find its solution. We have housing plans. We have gardens by the thousands for our employees. We have clubs and classes. We have entertainments and socials. We have free clinics and visiting nurses and social service workers. We have bonus systems and plans of profit sharing and a score of other lines of welfare work all trying for the one goal of making the worker a more efficient and better satisfied man. All of these things are good and should have a great deal more of our attention. They should be encouraged among our workmen and should be given larger appropriations of money. We have but to look into our own lives to see how easily men are thrown off their guard. We know that a night without proper rest is fatal to our highest efficiency on the day following, and we know that a long stretch of hard work without periods of proper relaxation and recreation will bring about a breakdown in our better judgments. We may not suffer a broken foot from a falling pig of iron or a burned ankle from a splash of molten metal, but we have accidents in our mental processes which are just as painful and a great deal more costly in dollars and cents. Perhaps we should have a great deal more serious accidents than the foundry laborer has if we carried our load and worked where he works and under the same conditions.

Mental Contentment a Great Safety Factor

We know that everything we do in our leisure time has its effect upon our lives while we are at work. The thing that is true of the executive who works in ideal surroundings is still more true of the man who labors with his hands and earns his living in the heat and smoke and confusion of our foundries. To a very large extent he is made or unmade by the things which happen to him outside of his workday life. So then we may say that a divorce suit in a local court may be more dangerous to the man involved than an open pit near his work bench. A threatening landlord may produce more injuries in our foundry than our worst hazard of equipment. In other words, the man whose mind is ill at ease or who isn't properly housed and fed may make our plant more unsafe than it would be if we removed every safety device in the whole place. The man who was just born careless and never outgrew it is more dangerous to our plant when he is in there at work than he would be if he stood off at a safe distance on the outside and hurled firebrands into it three times a day.

The Misfit

Now let us look at some of these men of ours who are so prone to injury. Let us make up our minds to help them if we can. The effort will pay for itself in many ways. First, there is the man who is a misfit. We didn't know there was such an animal a few years ago, but we are beginning to recognize him now. There are men in all of our foundries who ought not to be there. They have been drawn into our employ through a chain of circumstances and it is hard for them to break away. They belong there just about as much as the members of the National Safety Council belong in the business of deep-sea diving. They have about as much sympathy for our business as the average safety

*Abstract of paper read at the Eighth Annual Safety Congress of the National Safety Council, Cleveland, Ohio, October, 1919.

engineer has for the business of the steeplejack. Not having interest in their work, they lack the incentive to become efficient workmen. They drag through the day without enthusiasm and leave when the whistle blows with a full quota of accidents piled up behind them. These are the men who make our State Industrial Commissions keep one eye on our accident charts. It is because of such men as these that we have a high rate of industrial insurance for our foundries of all types.

Need of a Better Understanding of the Men's Abilities

But they are there. Our foreman can point out half a dozen of them any time we ask him. We know they are there, but what are we going to do with them? That question is easier to ask than it is to answer. Perhaps the easiest thing would be to give such a man the opportunity to find work somewhere else. We would have done that in the old days, but we hesitate to do it now; not that we love the man any more than we did, but it is not so easy to replace him with a better man. Another and better solution is to give him his opportunity in some other part of our own plant if possible. We know this plan will work, because we can all call up a great number of individual cases where it has worked. The trouble is that very few if any of us have adopted it as a principle for everyday application. The consistent application of this principle will eliminate a great many of our misfits. It will make careful and efficient workmen out of a great many of our accident makers and will often be the means of keeping a valuable man on our payroll. Of course we can't do this by merely saying that it will be done. If we believe it we must work it day after day, week in and week out. It will call for a closer co-operation between our different production departments and between all foremen and the employment department.

We cannot lay down any rules for the application of this principle. Each case must be handled in its own way. We shall understand our men better; at the very least, our men will understand us better and in this we shall have more of their loyalty and devotion.

The Man With Personal Troubles

The next man who is a great maker of accidents is the man whose mind is ill at ease. He is not so easy to recognize and not so easy to deal with when we do find him. He may be troubled about any one of a score of things and very often there seems to be a combination of nearly all of them. He may be, under ordinary conditions, a very careful and loyal workman, but when "troubles a ton" fall upon him he loses his sense of proportions and all thought of safety for himself or others is crowded out of his mind. The secret of his trouble is that his mind is focused on his own personal problem, so, of course, it cannot be focused on his work. His own personal problems must be met and solved. Every plant needs a squad of sharpshooters who can hit the spot every time. Call them what you will: visiting nurses, social service workers or what not, but first find your men and women who have common sense and good judgment and then turn them loose with authority enough to ride over every precedent and break every rule of the plant if this be necessary to supply the one and only remedy for the worker who is in trouble. These personal contacts with the individuals of our work forces are important and should be carried out just as systematically as our contracts with our best customers.

The next man who makes us lie awake at night wondering what is going to happen next is the careless man. He was born that way or his life has been such that he has grown that way. Nearly all of us are careless to a certain degree, but we find men in all walks of life who are dangerously and criminally careless. We have all known men who continually keep others in trouble on account of their carelessness, but who seem to live under a lucky star and never get hurt themselves.

Educating the Careless Man

The fortunate thing about the careless man is that we can educate him both as an individual and *en masse*. We can appeal to him on the basis of loyalty to his family and the safety of those who work with him. The careless man of our plants can be helped with the "shotgun prescription" in the form of safety bulletins and various other educational activities. A downward curve on the accident chart may be made a matter of pride to them. The most careless man we have may become the most careful if he should suffer a serious hurt as the result of his folly or if he should inflict an injury upon a fellow worker. It should be said, however, that he probably will not rise to this new degree of efficiency on his own account, but that he may be led into it after a heart-to-heart talk with some member of the executive staff. Here again the personal contact is the thing that is most effective in gaining the desired end.

As we shall find some misfits who cannot be "fitted" and some personal problems we cannot solve, so we shall find some careless men we cannot cure. When we find a man like this, the best gift we can bestow is the pay-off slip. Our business has in it so many unavoidable hazards that we cannot afford to be hampered by the man who will not help us to make it as safe as possible.

Environment

Environment is directly related to efficiency and efficiency is a half-brother to safety. The man who works at a rate of speed which is normal to him as an individual will have fewer accidents than he would if he worked a great deal faster or a great deal slower. The piece worker, who, naturally, is interested in maintaining a high degree of personal efficiency, will have fewer accidents than the day worker who takes occasion to kill a block of time now and then. The one is keyed up to his normal pace with mind alert and with attention centered in his task, while the other takes the pace that will keep him out of trouble with the foreman. His mind may be a blank and his attention may be focused anywhere but on his work. It is not difficult to see the relation that exists between each of these men and the accident record of the plant where they work.

We may say with confidence that everything which has a bearing on the productive labor of our men has also a bearing upon our accident experience. Everything which takes the attention of our men from their work will be reflected in the number of accidents we have and everything we do to improve working conditions will mean not only a higher rate of production but also a lower rate of injury.

Responsibility for the environment of the plant does not rest upon the management alone. All who work in the plant have their share in this. The foreman who keeps his department as neat and clean as possible will produce more and better castings than the foreman who allows his men to work in a place that is constantly out of order. Just as the executive will do better work

in a well-appointed office that is kept clear of rubbish, so will the molder and laborer do better work if they are not compelled to climb over miscellaneous piles of slip boxes, bottom boards and broken ladles every time they move about the shop.

Proper Instruction

A man may be a good workman, even a master of his trade, but if he does not know *our* methods of doing work in *our* foundry he may cause any number of accidents to himself and others before he learns. No man should be turned loose alone on a job until he has learned all he can be taught about it. He should know all of its hazards and should be shown how his work is to be related to other work throughout the plant. He will work with more understanding and with a more sympathetic attitude of mind. These have a direct bearing on the question of his making a safe and efficient workman for us. The task of giving him this information should be assigned to a definite group of qualified men and the new man's acknowledgment of having received such instruction be made a part of his record.

All of these problems were greatly minimized in the old days when the workman lived in the home of his employer. The complexities of modern life will never permit us to return to this condition, but we must approach the ideal of the constant personal contact with our workmen if we would seek to minimize the problems of this our present day.

That there is nothing that is entirely new or original in the subject matter of this paper is well known to the writer. It is only hoped that by bringing these same things to our attention again and again we can be brought to see anew our obligation to those who work for us and with us. There is nothing new to be brought forward in this problem. It is the old problem of the relation between men. We have not entered into any new obligation to our men in this new day of great industrial activity. Our obligation is the same if we have one man or a thousand men working for us. It is that we shall give them all we can of ourselves so long as they are faithful and loyal and continue to give us the best that is in them.

Marion Gray Iron Foundry,
Marion, Ind.

Lewis Impact Machine

LIEUTENANT COMMANDER A. G. ZIMMERMANN, of the United States Naval Gun Factory, presented a very important discussion of Dr. F. C. Langenberg's paper on "Experimental Data Obtained on Charpy Impact Machine," during the recent Chicago meeting—briefly mentioned in CHEMICAL & METALLURGICAL ENGINEERING, Oct. 8, 1919 (vol. 21, p. 461). Mr. Zimmermann's remarks in which he describes the theory and operation of the curve-drawing vertical-drop machine devised by Lieutenant G. Q. Lewis, U. S. N., follow at length:

Dr. Langenberg's work serves to demonstrate the correctness of two principles which should be the basis of all inspection by the consumer of materials subject to shock where impact testing machines are not available or where the data on results with impact testing machines are not considered conclusive enough to form the basis for specifications.

These two principles are: (*a*) Acceptance of forgings need not necessarily be based on the performance of test bars pulled in the direction of the stresses that will be applied in service. (*b*) Material that has normal ductility in its weakest plane is a good shock-resisting material.

The first principle follows the fundamental idea that if the most unfavorable test of the material is definitely known, the inspector has good grounds for assuming that the remainder of the forging is as good or better, when viewed from any other angle, as the results on which he accepted the forging. This is the more reasonable since, as pointed out by Dr. Langenberg, it is not always safe to say that no transverse stresses will be set up when, theoretically, the stresses of service are longitudinal.

If the location of test specimens is to be determined beforehand, irrespective of the method of forging, there would be an undue incentive to the manufacturer to do excessive forging in the direction of the test specimen. It is undoubtedly true that the more forging material receives in one direction, beyond a certain point, the less will be its ductility at right angles to this direction—and this effect is much more marked in basic steel than in acid steel. Since sudden shock appears to search out the weakest plane of a forging, it is apparent that normal ductility in one direction should not be sacrificed for a good showing in ductility in another direction.

Naval Bureau of Ordnance Uses Langenberg's Principles

Dr. Langenberg's results, showing that the impact test follows somewhat the course indicated by the results of the transverse static test, are borne out by the fact that the Naval Bureau of Ordnance has been following the above principles of inspection for some time and a consultation of the records fails to disclose any failures of material in service that have been traceable to the failure of accepted material under normal shock conditions. However, impact tests should be the principal criterion of any shock-resisting material, and it is hoped that their use in both commercial and ordnance work will rapidly come into favor. It is considered imperative, however, for the general use of such a test, that conditions should be standardized in the beginning, so that no confusion or change of equipment will result upon the incorporation of a standard test in the specifications.

Standard Practice for Impact Test

It is considered that there should be an early decision as to standard American practice in the following particulars, in order that the impact test may become a part of the routine procedure of buying materials subject to sudden stresses:

1. A selection of either the pendulum or the vertical-drop type of impact testing machines.
2. A selection of either notched or unnotched bars.
3. If notched bars are selected, the immediate selection of a standard notch, so that the practice of playing with various types of notches, such as has been done in other countries, be nipped in the bud, and some consistent data will quickly be assembled.
4. If possible, the adoption of an impact test whereby the resistance of the material can be reduced to an

equivalent of lb. per sq.in., which will have a more definite meaning to the ultimate consumer of this country and will obviate the necessity of a tabulation of new units in the customary reports of physical test.

This last point is not so far removed from possibility as it may seem at first glance. What appears to be a very workable arrangement has been devised at the United States Naval Gun Factory, for use with a vertical-drop machine, by Lieutenant G. Q. Lewis, of the Navy, who was assigned this task in connection with the contemplated activities of the enlarged physical laboratory of the Gun Factory.

Description of Lewis Machine

The essential features of the apparatus consist of a weight *A*, Fig. 1, which is guided by a central shaft *B* and can fall from any predetermined height, striking a hardened plate *D* and rupturing in tension the standard test bar *C*, the ends of which are screwed into the lower end of the shaft *B* and the plate *D*, respectively. A bracket *E* suitably secured to the weight *A* engages a plunger *F* of a device that amplifies the vertical movement of the weight just before and during the period of rupture. A pencil record of the amplified movement is made upon a paper cylinder mounted on a drum *G*, which is rotated at a known constant speed by the motor *H*. The object of the amplification is to obtain a space-time curve of such

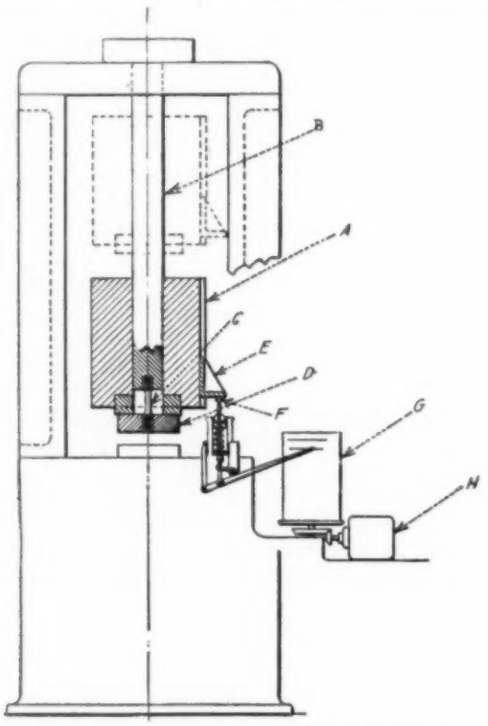


FIG. 1. VERTICAL DROP MACHINE

proportions that a graphic or protractor analysis may be conveniently and accurately made and the resisting value of the material tested derived in terms of lb. per sq.in.

Relation Between Elongation and Time

The curves obtained show the relation of the elongation of the test bar with reference to time. For a typical curve (see Fig. 2), the elongation would be measured vertically and the time horizontally to known scales, depending on the amplification and surface speed of the drum. The weight, being released from a suitable predetermined height, accelerates uniformly and attains maximum velocity at a certain point *J* where the pencil line crosses a horizontal base line *KL*, previously scribed on the drum with the weight resting on the plate *D*, Fig. 1, which is screwed to the lower end of the test bar. The tangential motion of the paper drum being to the left, the rupture curve is drawn

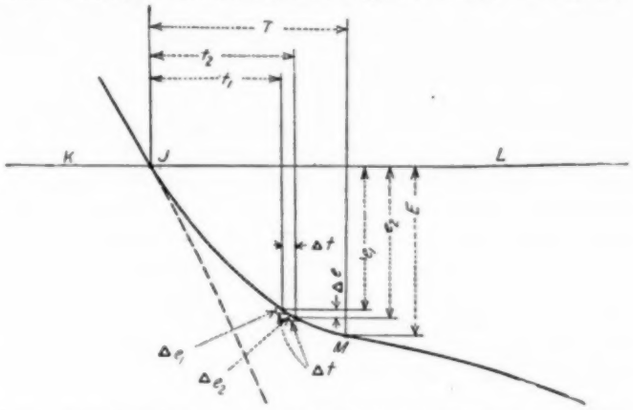


FIG. 2. RELATION OF ELONGATION OF TEST BAR WITH REFERENCE TO TIME

downwardly and to the right. Above the base line is recorded the last portion of the parabolic free fall of the weight and below is recorded the movement of same as retarded by the resistance of the test bar. The curve reverses after crossing the base line and the slope of the same decreases as the bar elongates, owing to the reducing velocity of the weight. After rupture occurs at M, the curve reverses and the weight again accelerates, due to gravity.

Analysis of the Results

Analysis of the curve between the initial and the final points of test-bar resistance gives the average forces of retardation corresponding to increments of elongation, Δe, measured normally to the base line. To determine the average retarding force during any time increment Δt, the slopes or tangents of the curve are first obtained at the beginning and the end of the time increment Δt, to determine the corresponding instantaneous velocities of the weight at these points. Thus the tangent to the curve or its equal, the instantaneous velocity of the weight at the beginning of time increment $\triangle t$, is $\frac{\triangle e_1}{\triangle t}$ and at the end is $\frac{\triangle e_2}{\triangle t}$. The acceleration during the period $\triangle t$ is $\frac{\triangle e_2 - \triangle e_1}{\triangle t^2}$.

The average force of retardation F, in pounds, during any increment of time Δt, therefore, equals the product of the mass and the acceleration, or $K\frac{\triangle e_2 - \triangle e_1}{\triangle t^2}$, where K is a constant depending on the mass of the weight and the units employed in measuring Δe and Δt. F will be algebraically negative because the acceleration is negative. Thus the stress, exerted by the test bar to resist the retardation force of the weight W, will be $+F$, since it is equal but opposite in direction to that imposed by the weight. The total stress in the bar will then be algebraically equal to $W + F$, where W is the number of pounds in the weight, also resisted by the test bar because of gravitation.

It is not to be assumed that calculations of this description will be necessary for each specimen pulled.

as a protractor has been designed which will integrate the space-time curve throughout the entire elongation period of the specimen and thus permit a ready selection of critical values, read directly in lb. per sq.in.

Advantage of the Lewis Testing Method

While Lieutenant Lewis, who has now returned to his former activities in the supplying and testing of railroad materials, had the benefit of previous research in connection with railroad shock absorbers, it is considered that this method of analysis is considerably different from any performed before, in that it goes further and gets an expression of the strength of material, in pounds per square inch, which is a function of the amount of energy expended in rupturing the specimen.

Oil Pipe Lines*

By S. A. Sulentic

THE object of this paper is to show the advantages of the oil engine as a means of transporting oil for long distances through pipe lines, to compare the cost of pipe-line transportation with that of rail and canal transportation, and to derive simple formulas that will make it comparatively easy for any one to make quick calculations of the pressure, net horsepower and brake-horsepower necessary for the transmission of any quantity of oil per day through a pipe of known diameter.

The cheapest method of overland transportation of oil is by pipe line. The cost in comparison to rail transportation is low, and yet when the rail cost is based on everyday practices, the amount seems very small. For instance, the management of an Eastern railway, wishing to impress upon its clerical employees the importance of economy, posted the following notice: "For every lead pencil you waste we have to haul one ton of freight one mile."

The cost of a pencil has always been regarded as being insignificant, but when it is considered that it is equivalent to the cost of the above-mentioned haul, a similar comparison with pipe-line transportation should be interesting. The carrying of one ton of freight for one mile at the cost of a lead pencil is very cheap transportation. One or two cents per ton-mile is a low rate. Canal transportation, after allowing for the proper fixed and maintenance charges, may be lower than the rail charges by 60 per cent or even more.

In order to make a very crude estimate of the cost of transporting oil by pipe line when using equipment of the highest economy, assume a single line operating under the following conditions at a load factor of 80 per cent for 300 days per year:

Size of line, in.	8
Length of line, miles	33
Pressure of line, lb. per sq.in.	700
Rate of discharge, bbl. per hr.	900

At this rate the discharge would be 21,600 bbl. per day, or 6,480,000 bbl. per year of 300 days. Assuming 6.5 bbl. per ton, the yearly discharge would approximate 1,000,000 tons. The work equivalent of this discharge would be 33,000,000 ton-miles, calling for the continuous expenditure of 257 hp. Assuming the mechanical efficiency of the engine to be 75 per cent, the actual horsepower necessary to install would be 257 ÷ 0.75, or 342.

The assumed costs would be as follows:

Line: 33 miles at $1.65 per ft.	$287,500
Right of way at $0.25 per rod	2,640
Freight: 79 cars at $250	19,750
Haulage: 900 tons at $14.50	13,050
Laying pipe at $0.075 per ft.	13,060
Burying pipe at $0.20 per ft.	34,850
Engines, pumps, installed accessories	68,500
Pump stations, buildings and foundations	30,000
Tanks: Two 55,000-bbl. at $18,500 each	37,000
Tanks: Two 500-bbl. at $500 each	1,000
Telegraph line: 33 miles at $550	18,150
Superintendence	2,500
Incidentals	6,000
Total assumed costs	$534,000

The operating expense, including fixed charges based on the total assumed costs, would be as follows:

Interest at 6 per cent	$32,040
Depreciation at 5 per cent	26,700
Administration	10,000
Attendance at pump stations and lines	11,500
Repairs to equipment, lines, etc.	4,000
Fuel for pumping—3,000 bbl. at $2.65	7,950
Total operating expense	$92,190

Hence the cost of operation per ton-mile under the assumed conditions would be $92,190 ÷ 33,000,000 = $0.0028, or two and eight-tenths mills per ton-mile. As the relation between the cost of pipe-line transportation and rail transportation is in the ratio of 1 to 10, it is easily seen that the waste of a lead pencil in a pipe-line enterprise would be the equivalent of the cost of transporting 10 tons of oil one mile.

Considerations in Estimating Cost

It should be noted, however, that almost all of the pipe-line costs are fixed and are mainly independent of the amount of oil pumped. As a result, the transportation cost per ton-mile will vary almost inversely with the load factor of the line. If this hypothetical pipe line should be operated only one-tenth of the time assumed, the unit transportation cost would equal the rail cost. Furthermore, these figures are based on a life of 20 years (5 per cent amortization). A railroad would probably be used for various classes of freight as long as it existed, but a pipe line is of service only as long as oil is presented for transportation. If the pipe line in question were to become obsolete in ten years through the exhaustion of the oil fields or other causes, the ton-mile cost would be greatly increased.

These figures have not been presented as those of an average case but on'y offered as "food for thought." In further consideration of the subject, however, it will not be out of place to give a few figures and examples showing the relations existing between pressure, capacity, diameter, length of line and power required.

Disregarding viscosity, the general hydraulic formula for friction head in a pipe discharging a uniform volume is

$$F = k\frac{v^2 L}{2gD} \qquad (1)$$

in which

F = friction head in feet of water = lb. per sq.in. ÷ 0.433
k = friction coefficient for 38 gravity oil = 0.024
v = velocity of flow, ft. per sec.
g = acceleration of gravity = 32.2 ft. per sec. per sec.
L = length of line, ft.
D = diameter of line, ft.

The formula for pressure in the line may be stated as

$$P = 0.433k\frac{v^2 L}{2gD} \qquad (2)$$

in which P = pressure in line in lb. per sq.in.

*Presented at the annual meeting, Dec. 2-5, 1919, of the American Society of Mechanical Engineers, New York.

The discharge Q of the line, cu.ft. per sec., can be easily derived and stated as

$$Q = \frac{\pi D^2 v}{4} \qquad (3)$$

in which Q varies directly as v. Since P varies directly as v^2 in Formula (2) and Q varies directly as v in Formula (3), it follows that P varies directly as Q^2.

The net horsepower required for a pipe line may be most readily calculated if we note that the pressure per sq.ft. is equal to the number of foot-pounds required to displace 1 cu.ft. of oil, or

$$\text{Hp.} = \frac{144PQ}{550} \qquad (4)$$

For 1,000 bbl. per day against a pressure of 1,000 lb. per sq.in., the net hp. necessary by Formula (4) would be

$$\text{Hp.} = \frac{144 \times 1{,}000}{550} \times \frac{1{,}000 \times 5.61}{24 \times 60 \times 60} = 17$$

where 5.61 = cu.ft. per bbl.

Assuming a pump efficiency of 85 per cent, the horsepower of the engine would be 17 ÷ 0.85, or 20. Here we have a very simple rule for calculating the horsepower from bbl. per day and pressure in lb. per sq.in.; namely,

Net hp. = 17 × thousands of bbl. per day × P ÷ 1,000

B.hp. = 20 × thousands of bbl. per day × P ÷ 1,000

For example, for a discharge of 8,000 bbl. per day against a pressure of 600 lb. per sq.in., the brake-horsepower required would be 20 × 8 × 0.6, or 96. Since the horsepower varies directly as PQ and P varies directly as Q^2, it follows that hp. varies directly as Q^3. To sum up:

Velocity varies directly as the line discharge.

Pressure varies directly as the square of the line discharge.

Horsepower varies directly as the cube of the line discharge.

Another relation of value in making rapid pipe-line calculations is the ratio between the diameter D and length L, with the discharge Q and the pressure P remaining constant.

From the friction formula (2) it will be seen that P varies directly as $v^2L \div D$. Assuming P constant, L varies directly as $D \div v^2$. For the same discharge, Formula (3), that is, with Q constant, v varies directly as $1 \div D^2$. Therefore v^2 would vary directly as $1 \div D^4$. Substituting this value for v^2 above, it is seen that L varies directly as $D \div (1 \div D^4)$, or in other words, L varies directly as D^5.

This means that for the same discharge and pressure, i.e., the same friction, the length of the line would vary directly as the fifth power of the diameter. Taking a diameter of 6 in. as unity, the fifth powers of several different diameters are as follows:

D =	6	8	10	12
D^5 =	1.0	4.2	12.8	32

An example will show how easily these relations are utilized. Let a proposed pipe line be made up as follows:

Two 6-in. lines, 8 miles long (Y-branch).
One 6-in. line, 6 miles long.
One 8-in. line, 10 miles long
One 12-in. line, 12 miles long.

With the particular oil to be transported the pressure per mile when pumping 10,000 bbl. a day through a 6-in. line will be assumed as 20 lb. per mile. What, now, will be the pressure for 17,000 bbl. per day through above line and what will be the net hp. and b.hp. required?

Since P varies as Q^2, the pressure for 17,000 bbl. will be $(17{,}000 \div 10{,}000)^2$, or 2.89 times the pressure for 10,000 bbl. The pressure in the line would then be 2.89 × 20, or 57.8 lb. per mile.

Inasmuch as the velocity is halved when using two 6-in. lines for the 8-mile section, each line carrying an equal amount of oil, the equivalent length of 6-in. line for each branch would be only two miles, the length varying directly as the square of the velocity. The length of 6-in. line equivalent to the 8-in. pipe would be 10 miles divided by the ratio of the fifth powers of the diameters 6 in. and 8 in., or 10 ÷ 4.2 = 2.38 miles. In a like manner the length of 6-in. line equivalent to the 12 miles of 12-in. pipe would be 12 ÷ 32, or 0.37 mile. In other words, the equivalent length of 6-in. pipe in the line under consideration would total 12.75 miles. Under a pressure on the line of 57.8 lb. per mile, the total pressure on the line would be 12.75 × 52.8, or 737 lb.

Making use of the simple formula for hp. already derived we have

$$\text{Net hp.} = 17 \times \frac{17{,}000}{1{,}000} \times \frac{737}{1{,}000} = 213$$

$$\text{B.hp.} = 20 \times \frac{17{,}000}{1{,}000} \times \frac{737}{1{,}000} = 250$$

No doubt many other useful relations could be derived for the purpose of expediting pipe-line calculations, but those which have been presented are among the most useful.

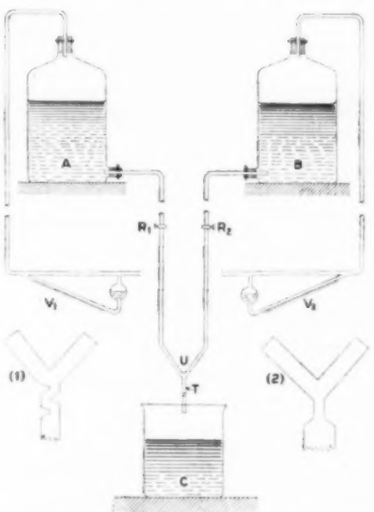
In illustration of the foregoing the following data in regard to the 36-mile, 8-in. Alton pipe line operating between Carlton and Wood River, Mo., should prove of interest. This line, constructed in 1913, has four stations, in each of which are installed four units each consisting of a 100-hp. type F. H. De La Vergne oil engine direct-connected to a 6-in. by 18-in. National Transit Co. herringbone-geared power pump with 8-in. suction and 6-in. discharge. The performance of one station equipment (three units) is given below:

Oil pumped during 10 days, bbl.	140,000
Oil pumped per day, average, bbl.	14,000
Pressure maintained in line, lb. per sq.in.	700
Brake horsepower, average	196
Pump efficiency, estimated, per cent	85
Fuel consumed by engines during 10 days, bbl.	65.8
Fuel consumed by engines per day, lb.	2,020
Brake-horsepower-hours per day = 196 × 24	4,704
Fuel consumption per b.hp.-hr., lb.	0.43
Ft.-lb. of work per day developed by the engines = 196 × 33,000 × 24 × 60	9,320,000,000
Ft.-lb. of work per day in oil pumped = 9,320,000,000 × 0.85 (85 per cent efficiency)	7,900,000,000
B.t.u. in fuel consumed per day = 2,020 × 18,000	36,000,000
Ft.-lb. of work per 1,000,000 B.t.u.	217,000,000
Daily operating cost:	
Fuel oil: 6.58 bbl. at $1.50	$9.87
Lubricating oil: 2 gal. at $0.22	0.44
Cylinder oil: 1.6 gal. at $0.21	0.34
Attendance: Total salaries of 2 engineers, 2 assistant engineers, 1 chief engineer and 2 telegraph operators	41.50
	$52.15
Cost per b.hp.-hr. ($52.15 ÷ 4,704)	$0.011
Cost per bbl. of oil pumped ($52.15 ÷ 14,000)	0.0037
Bbl. of oil pumped per bbl. of fuel consumed (14,000 ÷ 6.58)	2,130

In conclusion it may be said that the comparatively small amount of power involved in pipe-line transportation lends itself admirably to the efficient use of the oil engine as a prime mover. And unless some other form of power can show better results in the immediate future, the oil engine bids fair to hold its present superiority as a means for the transportation of oil.

Synopsis of Recent Chemical and Metallurgical Literature

Homogeneous Liquid Mixtures.—PIERRE JOLIBOIS has devised a very convenient apparatus for producing a homogeneous mixture of liquids in a very short time. The principle of the apparatus is described in the Dec. 8, 1919, issue of *Comptes Rendus*. The accompanying illustration shows the principle involved. The quantities of the liquids used are measured by the graduated venturi tubes, V_1, V_2. The diameter of the tube T and its shape have a great influence on the time required for homogeneous mixing.



APPARATUS FOR PRODUCING QUICKLY A HOMOGENOUS MIXTURE OF LIQUIDS

To render this visible to the eye he used in A a solution of potassium permanganate (1.58 g. per liter) and in B a solution of ferrous sulphate (15 g. $FeSO_4$, 50 c.c. conc. H_2SO_4 and 10 g. $MnSO_4$ per liter). The rapidity of the flow of liquids from the bottles A and B is regulated by the valves R_1 and R_2.

With a flow of 500 c.c. per min., the following data were obtained:

Dia. of Tube, Mm.	Length of Still Colored Liquid in Tube T, Cm.	Time Required to Obtain Homogeneity, i. e., When the Liquid Becomes Colorless, Sec.
2.5	4.0	0.04
3.2	6.5	0.08
4.8	10.0	0.2
6.2	22.5	1.0
8.5	33.0	1.2

The influence of the shape of the Y tube is shown by the following results:

Shape	Dia. of Tube in Mm.	Length in Cm. of Still Colored Liquid in Tube T	Time to Obtain Homogeneity, Sec.
Straight Y	6.2	22.5	1.00
1	6.2	4.0	0.12
2	6.2	2.6	0.01

The shape 2 has been adopted. This apparatus will be of great help in the study of the rapidity of reactions between liquids.

Catalytic Preparation of Ether.—The preparation of ether from alcohol by the use of moderately calcined commercial alum catalyzer has been studied experimentally by A. MAIHLE and F. DE GODON, in order to determine the influence of temperature, degree of alcohol and amount of catalyzer, and is described in the October, 1919, issue of *Bulletin de la Société Chimique de France*. The catalyzer is placed in a glass tube and heated, alcohol drips into the tube and vaporizes, the outgoing vapors are condensed and the ether is extracted from the catalyzed product.

Influence of Temperature. There was catalyzed 100 c.c. of 95 deg. alcohol in a glass at 175, 185 and 190-195 deg. C. The amounts of 0.725 density ether obtained were 10, 15, 20 c.c.; i.e., 11.8, 17.7 and 23.6 per cent efficiency respectively. This indicates that the best working temperature is 190-195 deg. C.

Influence of Degree of Alcohol. The following results were obtained when working on 100 c.c. of different degrees of alcohol under the same conditions of temperature and catalyzer:

Deg. Alcohol	Ether 0.725 Dens.	Efficiency
95	42	49.8
90	38	47.7
80	28	39.6
60	17	32.2

This shows that although 95 deg. alcohol gives the best results, it is possible to obtain relatively fair results from lower degrees of alcohol.

Influence of Amount of Catalyzer. When using the same amount of catalyzer but spread on a larger area, the results are not improved. By increasing the amount of catalyzer the efficiency increases as follows: 100 c.c. 95 deg. alcohol at 195 deg. C. gives with a 34-g. catalyzer 23.6 c.c. 0.725 ether; with a double 34-g. catalyzer 42 c.c. ether; with a quadruple 34-g. catalyzer 53 c.c. ether, and with a quadruple 42-g. catalyzer, 60 c.c. 0.725 ether, i.e., respectively 23.6, 49.8, 63 and 71.3 per cent efficiency.

The conclusions to which they arrived are:

1. Possibility of use of a cheap catalyzer, such as commercial alum.

2. Use of relatively low temperature, 195 deg. C. being the highest and at the same time the best suited for efficient results.

3. The ether obtained is pure, with no formation of ethylene and only traces of aldehyde.

4. Alcohols of even 55 to 60 deg. can be used with relatively fair efficiency.

Production of Hydrocyanic Acid.—The December, 1919, issue of *Helvetica Chimica Acta* contains a description of the research work of E. BRINER and A. BAERFUSS on the production of hydrocyanic acid. All the hydrocarbons mixed with nitrogen give HCN under the action of electric discharges. They have used pure methane and nitrogen with and without the admixture of hydrogen. The mixture of gases circulate at a rate of 8 to 10 liters per hr. in a chamber in which electric discharges take place. By using platinum electrodes spaced 7 mm. apart and with a current of 0.02 amp. under varying compositions of the gaseous mixture, voltages and pressures, the following results were obtained:

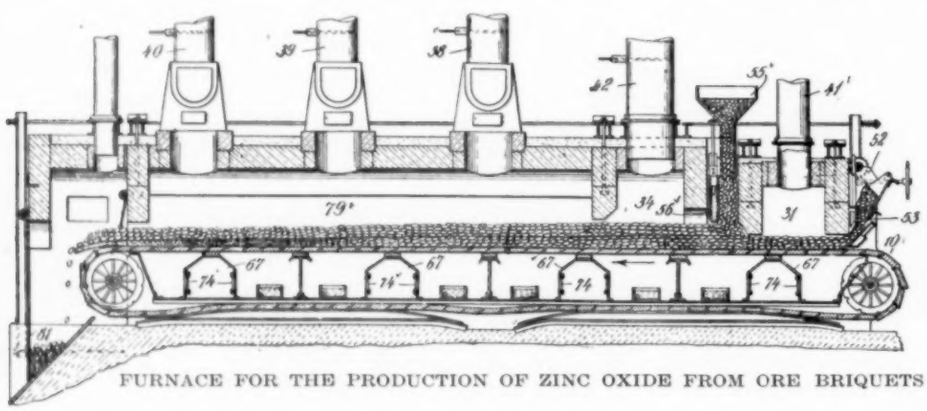
Composition of the Gaseous Mixture	Voltage	Pressure of Gaseous Mixture, Mm. Mercury	Efficiency G. per Kw.-hr. HCN	Efficiency G. per Kw.-hr. NH_3	Concentration HCN per Cent Volume
$12CH_4 + 23N_2 + 65H_2$....	1,020	635	0.46	0.14	0.08
$11CH_4 + 54N_2 + 25H_2$....	1,030	600	2.15	0.01	0.38
$CH_4 + N_2$.....	450	100	3.88	0.44	0.30
$CH_4 + 3.5N_2$.....	500	100	5.12	0.52	0.44
$CH_4 + 5N_2$.....	505	100	7.39	0.48	0.75
$12CH_4 + 23N_2 + 65H_2$....	420	100	1.75	0.44	0.12

They conclude that when working on a mixture with an excess of nitrogen under low pressures the results are far more satisfactory than when working under high pressure.

Recent Chemical and Metallurgical Patents

Complete specifications of any of the United States patents may be obtained by remitting 10c. each to the Commissioner of Patents, Washington, D. C.

Production of Zinc Oxide.—A series of patents assigned to the New Jersey Zinc Co. disclose improvements in the production of metal oxides and other compounds of metals by volatilization. In the production of zinc oxide by means of the Wetherill process the furnace grate is charged with a layer of "buckwheat" anthracite, which is ignited by the residual heat of the previous charge and a rapid combustion of this coal produced by forcing a blast of air through the perforated grate. Upon this ignited bed of coal is charged a mixture of finely divided coal and zinkiferous material termed the "working charge." The air blast is continued and when the volatilization is begun the fume is conveyed through cooling towers and collected in a baghouse. There are certain defects in this method. The formation of blowholes in the charge produces hot spots, making it necessary to work the charge by hand rabbling; in this way dust is carried off with the fume. Further, the necessity of maintaining a porous charge limits the fineness of the materials that can be used successfully. These and other objections are overcome by briquetting the fuel, which may be any carbonaceous material such as the smaller sizes of buckwheat coal, colliery washings or coke breeze, and also briquetting the zinkiferous material with the necessary amount of similar carbonaceous material. The fuel briquets are charged on the grate in the same manner as the "buckwheat" anthracite and after ignition the "working charge" briquets are added. (F. G. BREYER, J. A. SINGMASTER and A. E. HALL, 1,322,088; Nov. 18, 1919.)



FURNACE FOR THE PRODUCTION OF ZINC OXIDE FROM ORE BRIQUETS

As the Wetherill process is usually conducted, from 15 to 25 per cent of the total carbonaceous material is charged as the fuel bed, the remaining 85 to 75 per cent being mixed with the zinkiferous material. All of the ash of the coal is mixed with the residue; this residue has a value depending somewhat upon the amount of ash with which it is contaminated for the recovery of metals that are non-volatile under furnace conditions, also for the production of spiegeleisen, etc. When using the fuel and ore in the form of briquets, only 15 to 25 per cent of the fuel need be briquetted with the ore, the remainder being used as fuel briquets. Under these conditions the work-off ore briquets retain their original shape and can be readily separated from the ash of the fuel. This not only increases the value of the residue but increases recovery to about 90 per cent, which is about 20 per cent greater than with the usual method. (F. G. BREYER, A. E. HALL, G. R. WALTZ. 1,322,089; Nov. 18, 1919.)

The details worked out as above are applied to the production of sublimed lead and leaded zinc oxide and other compounds of metals as well as to zinc oxide. (F. G. BREYER, A. E. HALL, G. R. WALTZ. 1,322,090; Nov. 18, 1919.)

It is possible to briquet a certain amount of ore containing zinc or lead or both with the fuel briquets, or to briquet the ore without the addition of a reducing agent. These and other combinations are incorporated. (F. G. BREYER, J. A. SINGMASTER, A. E. HALL. 1,322,091; Nov. 18, 1919.)

The usual Wetherill process for the production of zinc oxide is conducted in a block furnace containing several grates, with the idea of providing zinc oxide continuously by controlling the sequence of operations, the operation on the individual grates being intermittent. The use of the fuel and ore in the form of briquets simplifies the design of a furnace in which the operation can be carried out continuously. Such a furnace is shown in the figure. The chain or other similar grate 10 is moved in the direction of the arrow about 7 ft. per min. The fuel briquets are charged through hopper 52, being spread by a water-cooled gate 53, the vertical movement of which controls the amount of feed. The charge is ignited and the gases escape through flue 41. The ore, also in the form of briquets containing 15 to 25 per cent carbonaceous material, is fed through hopper 55, being spread by a water-cooled gate 56, which also controls the amount of feed. Products of combustion, together with a small amount of metal oxides, are carried off through flue 42. The major portion of the metals is reduced, volatilized and oxidized in the fume chamber 79, which is about 18 ft. in length, and is carried off through flues 38, 39 and 40. Air under pressure is supplied beneath the grate through tuyeres 74 in the side of air-box 67. The worked-off ore briquets are discharged into hopper 81 in substantially their original form. The ash from the fuel briquets is in the form of disintegrated clinker and may be readily separated from the ore briquets. The bed of fuel briquets used is about 6 in. deep and the bed of ore briquets about 3 in. deep. Chamber 31 is maintained at a temperature of between 800 and 850 deg. C., which is a minimum temperature for uniform ignition. Satisfactory working temperatures for chamber 34 are from 1,000 to 1,050 deg. C. and for the fume chamber 79 from 1,100 to 1,250 deg. C. The temperature is controlled by slide dampers located in the air flue leading to air chambers 74 and also by dampers in the flues 38, 39, 40 and 42. A recovery of about 90 per cent of the volatile metals is obtained at a considerable reduction in labor. The quality of the product is also improved due to the avoidance of dust. (J. G. SINGMASTER, F. G. BREYER and E. H. BUNCE. 1,322,142; Nov. 18, 1919.)

The furnace and details are applied to the production of sublimed lead, leaded zinc oxide and other compounds of metals as well as to zinc oxide. (J. G. SINGMASTER, F. G. BREYER and E. H. BUNCE. 1,322,143; Nov. 18, 1918.)

Electrolytic Oxidation of Benzene to Quinone.—The oxidation of benzene to quinone is accomplished in the anode compartment of an electrolytic cell. The lead anode is provided with a large number of staggered projections so that the benzene, which is introduced through a perforated tube near the bottom of the electrode, is forced to follow a devious course in rising to the surface of the electrolyte (10 per cent sulphuric acid). A current density of 0.5 amp. per sq.dm. is used and the temperature is kept below 12 deg. C. An excess of benzene is used, so that the quinone formed remains in solution. This solution of quinone in benzene is removed to a reduction tank, where it is treated with sulphurous acid. The quinone is reduced to quinol (hydroquinone), which may be recovered from the aqueous solution by evaporation. The excess benzene is returned to the electrolytic cell. (1,322,580; FREDERICK T. KITCHEN, of West Brighton, N. Y., assignor, by mesne assignments, to K. & T. Chemical Corp.; Nov. 25, 1919.)

Pickling Baths.—WILLIAM H. ALLEN, of Detroit, Mich., notes that an ordinary pickling bath, as of sulphuric acid, attacks clean iron so much more rapidly than its adherent scale that sheets often emerge badly corroded. In order to reduce these higher iron oxides so they may more readily go into acid solution, he recommends the addition of about one-fifth the amount of sulphurous radical, by bubbling SO_2 or adding sodium bisulphite or hyposulphite. Other reducers which may be effectively used in the ordinary baths of sulphuric, hydrochloric or phosphoric acid are phosphorous acid, H_2S, Na_2S, or phosphides of iron or zinc. All of these produce active reducers, but great care is necessary in their use, as some products are violently poisonous or highly explosive. (1,321,182; Nov. 11, 1919.)

Book Reviews

STORING, ITS ECONOMIC ASPECTS AND PROPER METHODS. By *H. B. Twyford.* 252 pages, 6 x 9. 112 charts, diagrams and forms. New York, 1918: D. Van Nostrand & Co.

This work brings out splendid points in favor of giving the store department more consideration and attention than it usually receives from the managers of most industrial firms. The proper receiving, storing and distribution of supplies are an important factor in the welfare of any business institution.

On page 81 the author states that material can be placed on the shelves "at any time to suit conditions," while he contradicts on page 98 with "Prompt handling of all material as it arrives is an essential feature of successful storekeeping." The latter, of course, is true.

Prominent organizers of store departments of large concerns differ with the author in that they are opposed to the use of the perpetual inventory. The receiving clerk should not be separated from the store department, as recommended, but should report receipts to the storekeeper, who, in turn, notifies the purchasing agent. Excellent ideas are advanced for records of receipts of material. Provision for return of such goods as are not immediately used to the storehouse is also good.

The careful study of this book by the younger members of the store department forces would yield them valuable information, but discretion must be used in accepting any of the technical theories advanced. E. G. WALKER.

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SELENIUM CELLS AND HOW THEY ARE MADE. By *Samuel Wein.* 34 pages. New York: Progress Publishing Co.

This small book is of tablet form and contains a chronological survey of information concerning selenium and selenium cell construction. It has been written expressly for the investigator who is interested in the variation of the electric conductivity of selenium in the presence of light. While it may be justly criticized because of being overly concise, it does contain a great amount of valuable data as well as bibliography for the guidance of the reader.

WALLACE SAVAGE.

Personal

ALBERT BRETON, formerly vice-president of the Guaranty Trust Co., New York, has been elected president, to succeed GRAYSON M. P. MURPHY, who resigned to assume the presidency of the newly-formed Foreign Commerce Corp. of America.

ARTHUR R. CADE, formerly instructor in chemistry at the University of Minnesota, Minneapolis, Minn., is now associated as research chemist with the National Carbon Co., Fremont, Ohio.

JOHN J. CARTY, vice-president of the American Telephone & Telegraph Co., lectured under the auspices of the National Research Council on Feb. 6. The subject was "Science and the Industries."

Dr. VIRGIL COBLENTZ, formerly professor of chemistry in the New York College of Pharmacy and later chemical director of E. R. Squibb & Sons, Brooklyn, N. Y., and N. W. KEMPT, chemical engineer, will engage in professional consulting practice, with offices at 119 Nassau St., New York City.

Dr. HARRY A. CURTIS has resigned his professorship at Northwestern University, Chicago, to accept a position with the International Coal Products Co., New York.

WALTER S. ERNST, formerly employed as a chemist at the U. S. Nitrate Plant No. 1, Sheffield, Ala., is now chief chemist for the Ironton Portland Cement Co., Ironton, Ohio.

J. A. L. GALLARD, who was mining editor of the *Financial Times* for eighteen years, has joined the staff of the *Mining Magazine* as associate editor.

HAROLD GRAY, who has been on the research staff of Eli & Co. of Indianapolis, Ind., for the past four years, is now on the research staff of B. F. Goodrich Co., Akron, Ohio, in the organic development department.

G. P. HULST has resigned as assistant general manager of the East Chicago plant of the International Lead Refining Co. and will be succeeded by GUNNARD E. JOHNSON.

MILO W. KREJCI has become works manager for the Parish-Pool Co., Cleveland, Ohio. During the past few years Mr. Krejci has developed an electrolytic process for making a white lead and supervised the construction and operation of a commercial plant working under this process for the International Lead Products Co.

CLARENCE E. MEISSNER has accepted a position with the Inspiration Consolidated Copper Co., Inspiration, Ariz.

CHARLES F. RAND, who has been president of the United Engineering Society since 1917, has retired, his term having expired. By constitutional limitation he was not eligible for re-election. As an appreciation of Mr. Rand's services the board of directors of the American Society of Mechanical Engineers presented him with engrossed resolutions. J. VIPOND DAVIES succeeds Mr. Rand.

Provost EDGAR FAHS SMITH, of the University of Pennsylvania, has tendered his resignation, to take effect at the end of the present academic year, which will complete his forty-fourth year as a teacher.

E. K. SOPER, who has been with the Trinidad Petroleum Development Co. at Port of Spain, Trinidad, is now located at 120 Broadway, New York City, with the Sinclair Oil & Refining Co.

GEORGE J. YOUNG, Western editor of *Engineering and Mining Journal*, is in New York City to attend the meeting of the American Institute of Mining and Metallurgical Engineers.

Current Market Reports

The Non-Ferrous Metal Market

New York, Feb. 16—Copper market steady with little new business. Tin has advanced ¼c. over last week's quotation. Slight advances in lead, tin and silver.

	Cents per Lb.
Copper, electrolytic	18.75
Aluminum, 98 to 99 per cent	31½@32½
Antimony, wholesale lots	11.50
Nickel, ordinary	43.00
Nickel, electrolytic	45.00
Tin, Straits, spot	57.75
Lead, New York, spot	8.87½
Lead, E. St. Louis, spot	8.55
Zinc, spot, New York	9.05
Zinc, spot, E. St. Louis	8.70
Silver (Dollars per oz.)	1.34½

FINISHED METAL PRODUCTS

	Warehouse Price Cents per Lb.
Copper sheets, hot rolled	29.50
Copper sheets, cold rolled (over 14 oz.)	31.50
Copper bottoms	38.00
Copper rods	27.50
High brass wire and sheets	25.25
High brass rods	23.75
Low brass wire and sheets	27.25
Low brass rods	28.00
Brazed brass tubing	37.00
Brazed bronze tubing	41.75
Seamless copper tubing	33.50
Seamless bronze tubing	34.50
Seamless brass tubing	30.50

RARER METALS

Magnesium	lb.	$1.75@1.90
Cadmium	lb.	1.50
Cobalt	lb.	1.50
Platinum	oz.	150.00
Iridium	oz.	250.00
Palladium	oz.	150.00
Mercury	75 lb.	80.00

SCRAP METALS

	Cents per Lb.
Aluminum, cast scrap	23½@24½
Aluminum, sheet scrap	22½@23½
Aluminum clippings	25½@27
Copper, heavy machinery comp.	14½@14½
Copper, heavy and wire	13½@14
Copper, light and bottoms	12½@12½
Copper, heavy cut and crucible	15½@16
Brass, heavy	7½@8½
Brass, casting	10½@10½
Brass, light	5½@6½
No. 1 clean brass turnings	8½@8½
No. 1 comp. turnings	12 @12½
Lead, tea	5½@5½
Lead, heavy	6½@7
Zinc, scrap	4½@4½

The Iron and Steel Market

Pittsburgh, February 13, 1920.

The rate of production mentioned last week for January (85 per cent) has fallen off if anything, due to continued transportation difficulties. Deliveries of coke and metal have been even worse last week than previously, bringing some plants to a point where hand-to-mouth conditions exist between stock-pile and furnaces, while more than one stack has been banked over the week end to conserve materials for the ensuing week's operation. In addition to this, the excessively bad weather throughout the Atlantic and New England states has resulted in embargoes at many important points. Notably, the heavy storms in New York during the last week have paralyzed truck haulage in that vicinity and resulted in an embargo on everything for shipment east of Newark. Such a combination of events is discouraging to mills overwhelmed with insistent demands for prompt material; some mills are not getting enough supplies to operate on, and the others with ample reserve stocks, cannot get cars or engines to move the finished product.

Such conditions are food to a bull market. Buyers are more and more insistent for metal; the sky is almost the limit for small lots of prompt tonnage. Quotations are therefore impossible. The Steel Corporation is still holding to the March 21 schedule; its recent statement of unfilled tonnage indicates a booking rate fully 50 per cent above capacity, with orders now in sufficient volume to carry to December. A fortnight ago a rough average of prices being offered to independents would probably approximate what are known as "Jan. 1" prices, those to which the war-time figures were reduced shortly after the armistice. Despite the effort of one of the largest of the independents to maintain this general level, business is being done at $5, $10 and even $25 a ton above the fixed prices for the war period.

PIG IRON AGAIN UP

Pig iron is again up, following a short period of very heavy buying. Foundry is now at least $41, valley, with basic $43 taken for large tonnage and a disposition to charge even more for left-overs. Bessemer is about $42, valley. Southern foundry has been sold in Cincinnati territory during the week at $42, Birmingham, and this price is being quoted by a number of furnaces for the first half, but at least two of the larger interests are still booking for the rest of the year at $40.

The Ferro-Alloy Market

New York, February 13, 1920.

Ferromanganese continues active both in demand and price. One large firm with works in the Pittsburgh district has quoted as high as $170 a gross ton, other quotations varying from $160@$165. Actual sales at these prices are reported heavy and firm. A steady rise to $200 is looked for by men in the New York end of industry.

Spiegeleisen remains firm in price. Demand is rather brisk and a sympathetic rise is looked for soon. The quotation of $55@$60 f.o.b. Pittsburgh is still in force.

There has been slight movement in tungsten, although no actual orders were reported. The cause of this is evidently the desire of buyers to get it at the prevailing low prices. The looked-for settlement of the tariff situation one way or the other will probably send prices rocketing, as tungsten has been at a standstill since the latter part of last year. Present quotations are: Scheelite, 60 per cent WO_3, $10.50; wolframite, $7@$7.50.

Ferrosilicon holds firm on all grades, 50 per cent being $85 a gross ton; 75 per cent, $150, and 10 to 15 per cent, $65@$70, all quotations being f.o.b. Pittsburgh district.

The Chemical and Allied Industrial Markets

New York, February 16, 1920.

The recent storm has seriously tied up the chemical industry. Producers have been handicapped by a still further curtailment in coal supplies and spot trading has been practically at a standstill. Export business, which has been rather heavy on several items, cannot be filled because of shortage of cars for shipping. The willingness on the part of English buyers to do business in this country despite the extremely abnormal rate of exchange gives evidence of the scarcity of supplies in some lines.

GENERAL CHEMICALS

Trading during the past week has been confined mostly to small lots. *Sal ammoniac* remains in the same position, with the English stocks fast decreasing and an upward trend in the domestic material. *Barium chloride* continues active in demand, with stocks rather scarce. The present quotation is $85@$95 per ton, with some producers going as high as $100. *Bleaching powder* is practically off the spot market, with prices firm, varying from 2@3¼c. per lb. With the present demand a rise is looked for soon. *Blue vitriol* has been in heavy demand for domestic; while export business has fallen off slightly, present listing is 8¼c. per lb. The export demand on *caustic potash* remains firm, prices are steady and maintain the same level, of 23@32c. per lb., as the previous report. *Soda ash* remains unaffected by the recent drop in exchange, England being willing to meet these adverse conditions in order to obtain the material. This item is unobtainable on spot. The

present quotation is firm at $2.40 per cwt. *Caustic soda* is in the same position as soda ash. Foreign buyers are meeting the American producers' prices in order to obtain material which the extreme coal shortage has cut off.

Coal-Tar Products

The Bureau of Imports, War Trade Board Section, has recently sent out an application form to all dealers in coal-tar products and dyes regarding the importation into this country from Germany of German dyes. The purpose of this application is to restrain the flooding of the domestic market with these colors, thereby running domestic producers out of this industry. In order to obtain the German colors it must be testified to that these dyes are unobtainable in the United States, or if so on terms as to price, quality and delivery as are not considered reasonable. This application is then submitted to the board, which passes or rejects it. It is a question whether this or the tariff regulations is the better plan, but it is the opinion of nearly all that it should be given a trial.

With this question definitely settled a general expansion of plants and increased production is to be expected. *Aniline oil* stands firm, with considerable inquiry during the past week, at 34c. per lb., for forward delivery. *H acid* is unobtainable on spot and difficulty is experienced in getting it on contract, as producers are sold ahead. Prices as high as $1.65 per lb. have been reported. *Benzol* is somewhat easier, with producers offering some material on spot at 25c. per lb. for 90 per cent. *Dimethylaniline* continues scarce. The quotation is nominal, as there is none to be had. Prices as high as $1 per lb. have been reported. There has been no change in the quotation on *toluol*. There seems to be ample stocks of this material, and 28@32c. of last week still holds.

Naval Stores

It is heard on some sides that there is no scarcity in *spirits of turpentine* and that speculation is the cause of the sensational rise in this item to $2.04 per gal. There evidently is ground for holding both opinions. England is still a big buyer despite the high prices and the rate of exchange. The *rosins* are easier, with a noticeable drop in all grades which is caused by a slacking of demand.

Crude Rubber

The crude rubber market remains practically unchanged, but there is a slight undercurrent of firmness inspired by the English and Indian markets. Actual business has been very light, as buyers have shown no inclination to buy even at the comparatively low figures. *Para, up-river fine*, is down to 45@46c. per lb. and the coarse is listed at 33c. per lb. The plantation grades have been extremely quiet with no contract business reported.

Feldspar and Barytes

Feldspar remains unchanged. Manufacturers are reported sold up until end of the year. Difficulties in transportation, cold weather and scarcity of labor are further crippling this commodity. The Government price of $18 still prevails.

Barytes is still scarce. Contracts are not binding, as they may be broken by either party. If the cost of production increases after the contract is made, the producer may raise the price, but the buyer also has the privilege of refusing the goods if the price is too high. Barytes, white floated, $34@$36 per ton; off color, $22@$28 per ton.

Chicago, February 11, 1920.

Pine tar products, which have been under heavy foreign buying pressure for some time, can probably be expected to be a little easier in tone as a result of low exchange, but this reflex is not yet felt in this market.

Plenty of bids are made for goods, but large lots are frequently unobtainable. Short stocks are particularly troublesome as regards *flotation oils* and *fertilizers*, in both of which lines prices remain unchanged at a high level. It is probable that threatened rail labor troubles are causing buyers to proceed slowly also.

Heavy Chemicals: *Alcohol* is the product hardest to obtain, spot stocks of *methyl* being practically exhausted. When obtainable, 95 per cent goes at $1.90@$2 per gal. in small quantities, against a quotation of $1.80 two weeks ago. *Ethyl*, with a nominal quotation of $5.35 a gal. for 190 proof, is very uncertain in delivery. Actual sales of stock on hand have been closed as high as $7.50 in bbl. lots. *Formaldehyde*, which advanced so rapidly last month, is but little easier, current quotation being 45@48c. Small quantities only are available, and demand greatly exceeds offerings. Future orders for formaldehyde are being placed at 25@27c.

Caustic soda has eased off about a quarter of a cent, $4.25 per cwt. in carlots, f.o.b. works, now being quoted for granulated and $3.90@$4 for solid. Export shipments of *bleaching powder* have rendered it short, for immediate delivery, and $3 per cwt. in carloads is the ruling price. *Sodium bichromate* continues to fluctuate, present market being able to absorb all offers at 23@25c. per lb.

No other changes of moment are noted. The increase recently recorded in *roll sulphur* (brimstone) holds good, spot stock in bbl. being quoted at 5c., and carloads from factory at $3.80@$3.90 per cwt. *Acids* seem to have slightly more strength, *sulphuric* 66 deg., being quoted at $22 a ton in cars and *oxalic* at 42c. per lb. in bbl., against prices of $20 and 40c., respectively, two weeks ago. Threatened rail troubles which cause uncertainty in the steel industry tend to prevent much activity in the market for acids.

Coal-Tar Products: Quieter demand for crudes has eased up prices all along the line, and this condition is accentuated by freer offering of supplies. If no further interruption occurs to production or transportation, it is evident that prices will be appreciably lower than those ruling at present. *Benzol* in drums is back to 27c., from an earlier quotation of 33c., and *toluol* is changing hands at 28c. in tanks. *Anilines* are slightly easier, for spots, 34c. being the ruling price on oil and 44c. on salts. Demand seems light on these items, probably on account of the high price.

Benzoic acid now brings, in wholesale quantities, 90c. for U. S. P. and 75c. for technical grade, these items showing reductions of 5c. and 3c., respectively. *Salicylic acid* remains at the former quotation of 44c. for technical and 55c. for U. S. P. As expected, *picric acid* has advanced until it has now reached a price of 25c., which seems reasonable.

Vegetable Oils: Linseed is unchanged in price. There is but little trading. The condition seems to be that, with an Argentine crop of unknown proportions approaching, buyers do not care to invest heavily at present prices, and with flaxseed selling at better than $5, crushers cannot reduce prices. Present Chicago quotation on oil is around $1.75 per gal. in carlots and $1.98 in bbl. *Cocoanut oil* is also weak—probably owing to similar conditions—with miller grade in bbl. being quoted at 19c. in this market. *Soya bean oil* is stronger than the rest of the line, demand remaining fairly strong at 17½c., in sellers' tanks, f.o.b. Coast. Offerings in *corn oil* continue to exceed buyers' requirements, and *crude* is now quoted at 18¾c. in bbl., f.o.b. Chicago, *prime summer yellow* at 23@24c.

Flotation Oils; Naval Stores: Continued high prices have caused a marked decrease in turnover, but the market is holding firm. There has been no change in price recorded anywhere in the line. The one item in which stocks are short is *pine oil*. Spot stocks practically do not exist and dealers are uniformly refusing new business and are taking care of regular customers as well as possible at the old price of $1.50 per gal. in cars for both pure and destructively distilled.

Fertilizers: Buyers seem to feel that prices are too high, and as a result the market has been and is very quiet. Supplies are short, but what little changed hands went at record prices, *ground blood* being offered at from $7.90@$8.10 and *unground blood* at $7.75@$7.85. Similar increase occurred in prices asked for tankage, and but little business resulted. Current quotation for high-grade *ground tankage* is $7.65. Similar conditions prevail in trading in *bone meal*, prices ranging from the last quotation of $44 up to $48 per ton, f.o.b. Chicago, in carlots.

General Chemicals

CURRENT WHOLESALE PRICES IN NEW YORK MARKET

		Carlots	Less Carlots
Acetic anhydride	lb.	..... –	$0.60 – $0.65
Acetone	lb.	$0.16 – $0.20	.21 – .....
Acid, acetic, 28 per cent	cwt.	2.75 – 3.00	3.00 – 3.25
Acetic, 56 per cent	cwt.	5.25 – 5.75	6.00 – 6.50
Acetic, glacial, 99½ per cent, carboys	cwt.	12.00 – 12.50	13.50 – 15.50
Boric, crystals	lb.	.14½ – .15½	15½ – .16½
Boric, powder	lb.	.14½ – .15	.15 – .16
Hydrochloric	lb.	.08 –	.09 – .10
Hydrofluoric, 52 per cent	lb.	.12 – .12½	.14 – .....
Lactic, 44 per cent tech	lb.	.11 – .11½	.12 – .16
Lactic, 22 per cent tech	lb.	.05 – .06	.05½ – .07
Molybdic, C. P.	lb.	..... –	4.25 – 5.00
Nitric, 40 deg	lb.	.06 – .07	.07½ – .08½
Nitric, 42 deg	lb.	.06½ – .07	.08 – .09¼
Oxalic, crystals	lb.	.35 – .40	.40 – .45
Phosphoric, Ortho, 50 per cent solution	lb.	.24 –	..... – .....
Picric	lb.	.30 – .35	.40 – .50
Pyrogallic, resublimed	lb.	2.50 – 2.55	2.60 – 2.65
Sulphuric, 60 deg., tank cars	ton	17.50 – 22.00	..... – .....
Sulphuric, 60 deg., drums	ton	..... –	..... – .....
Sulphuric, 66 deg., tank cars	ton	22.00 – 25.00	..... – .....
Sulphuric, 66 deg., drums	ton	..... –	..... – .....
Sulphuric, 66 deg., carboys	ton	..... –	..... – .....
Sulphuric, fuming, 20 per cent (oleum) tank cars	ton	27.00 – 30.00	32.00 – .....
Sulphuric, fuming, 20 per cent (oleum) drums	ton	32.00 –	34.00 – .....
Sulphuric, fuming, 20 per cent (oleum) carboys	ton	35.00 –	40.00 – .....
Tannic, U. S. P.	lb.	..... –	1.35 – 1.45
Tannic (tech.)	lb.	..... –	.42 – .55
Tartaric, crystals	lb.	..... –	.69 – .74
Tungstic, per lb. of WO	lb.	..... –	1.20 – 1.40
*Alcohol, Ethyl	gal.	4.80 – 5.50	6.00 – 7.00
*Alcohol, Methyl	gal.	1.50 –	1.52 – 1.57
*Alcohol, denatured, 188 proof	gal.	..... –	.76 – .78
*Alcohol, denatured, 190 proof	gal.	..... –	.71 – .73
Alum, ammonia lump	lb.	.04½ – .05	.05½ – .06
Alum, potash lump	lb.	.08 – .08½	.09 – .09½
Alum, chrome lump	lb.	.15 – .16	.18 – .20
Aluminum sulphate, commercial	lb.	.01½ – .02	.02½ – .02½
Aluminum sulphate, iron free	lb.	.02½ – .03	.03½ – .03½
Aqua ammonia, 26 deg., drums (750 lb.)	lb.	.08¾ – .10¾	.11 – .12
Ammonia, anhydrous, cylinders (100-150 lb.)	lb.	.33 – .35	.35 – .37
Ammonium carbonate, powder	lb.	.13 – .16½	.17 – .17½
Ammonium chloride, granular (white salammoniac)	lb.	.14 – .15	.16 – .17½
Ammonium chloride, granular (gray salammoniac)	lb.	.13 – .13½	.14 – .14½
Ammonium nitrate	lb.	.22 –	..... – .....
Ammonium sulphate	lb.	.05 –	.06 – .....
Amylacetate	gal.	..... –	3.65 – 3.75
Arsenic, oxide, lumps (white arsenic)	lb.	..... –	.10½ – .11
Arsenic, sulphide, powdered (red arsenic)	lb.	.23 – .24	..... – .....
Barium chloride	ton	85.00 – 95.00	100.00 – 110.00
Barium dioxide (peroxide)	lb.	.22 –	.24 – .....
Barium nitrate	lb.	.11 – .12	.13 – .14
Barium sulphate (precip.) (blanc fixe)	lb.	.03 – .03½	.03¾ – .04
Bleaching powder (see calcium hypochlorite)		..... –	..... – .....
Blue vitriol (see copper sulphate)		..... –	..... – .....
Borax (see sodium borate)		..... –	..... – .....
Brimstone (see sulphur, roll)		..... –	..... – .....
Bromine	lb.	.90 – .95	..... – .....
Calcium acetate	cwt.	2.00 – 2.05	2.10 – .....
Calcium carbide	lb.	..... –	.04¼ – .05
Calcium chloride, fused, lump	ton	20.00 – 25.00	30.00 – 40.00
Calcium chloride, granulated	lb.	.01½ – .01¾	.02 – .02½
Calcium hypochlorite (bleaching powder)	cwt.	..... –	2.50 – 3.00
Calcium peroxide	lb.	..... –	1.50 – 1.70
Calcium phosphate, monobasic	lb.	..... –	.75 – .80
Calcium sulphate, pure	lb.	..... –	.25 – .30
Carbon bisulphide	lb.	.06 – .08	.09 – .10
Carbon tetrachloride, drums	lb.	..... – .11	.12 – .15½
Carbonyl chloride (phosgene)	lb.	..... –	.75 – 1.00
Caustic potash (see potassium hydroxide)		..... –	..... – .....
Caustic soda (see sodium hydroxide)		..... –	..... – .....
Chlorine, gas, liquid-cylinders (100 lb.)	lb.	.05 – .05½	.08 – .....
Chloroform	lb.	.28 – .29	.30 – .31
Cobalt oxide	lb.	..... –	1.50 – 1.55
Copperas (see iron sulphate)		..... –	..... – .....
Copper carbonate, green precipitate	lb.	.27 – .28	.29 – .31
Copper cyanide	lb.	..... –	.65 – .70
Copper sulphate, crystals	lb.	.08¼ – .09	.09 – .09¼
Cream of tartar (see potassium bitartrate)		..... –	..... – .....
Epsom salt (see magnesium sulphate)		..... –	3.00 – 3.25
Formaldehyde, 40 per cent	lb.	..... –	.42 – .52
Glauber's salt (see sodium sulphate)		..... –	..... – .....
Glycerine	lb.	..... –	.24½ – .26
Iodine, resublimed	lb.	..... –	4.10 – 4.30
Iron oxide, red	lb.	..... –	.03 – .20
Iron sulphate (copperas)	cwt.	1.20 –	1.25 – 1.75
Lead acetate, normal	lb.	.12 – .13	.14 – .23
Lead arsenate (paste)	lb.	..... –	.13 – .17
Lead nitrate, crystals	lb.	..... –	.70 – .80
Litharge	lb.	..... –	.09½ – .10½
Lithium carbonate	lb.	..... –	1.50 – .....
Magnesium carbonate, technical	lb.	..... –	.13 – .14½
Magnesium sulphate, U. S. P.	100 lb.	2.15 – 2.63	2.75 – 3.00
Magnesium sulphate, commercial	100 lb.	1.75 –	2.00 – 2.50
Nickel salt, double	lb.	.14 –	.15 – .....
Nickel salt, single	lb.	.16 –	.17 – .....
Phosgene (see carbonyl chloride)		..... –	..... – .....
Phosphorus, red	lb.	..... –	.60 – .65
Phosphorus, yellow	lb.	..... –	.35 – .37
Potassium bichromate	lb.	.32 – .33	.34 – .35
Potassium bitartrate (cream of Tartar)	lb.	..... –	.56 – .60
Potassium bromide, granular	lb.	..... –	.50 – .65
Potassium carbonate, U. S. P.	lb.	.60 –	.65 – .70
Potassium carbonate, crude	lb.	.26 – .27	.28 – .30
Potassium chlorate, crystals	lb.	.16 – .20	.21 – .....
Potassium cyanide, 98-99 per cent	lb.	nominal	..... – .....
Potassium hydroxide (caustic potash)	lb.	.28 – .32	.35 – .42
Potassium iodide	lb.	..... –	3.35 – 3.60
Potassium nitrate	lb.	.19 –	.21 – .....
Potassium permanganate	lb.	..... –	$0.65 – $0.95
Potassium prussiate, red	lb.	1.00 – 1.05	1.10 – 1.20
Potassium prussiate, yellow	lb.	..... –	.40 – .70
Potassium sulphate	ton	$225.00 –	..... – .....
Rochelle salts (see potas. tartrate)		..... –	..... – .....
Salammoniac (see ammonium chloride)		..... –	..... – .....
Sal soda (see sodium carbonate)		..... –	..... – .....
Salt cake (sodium sulphate)	ton	18.00 – 21.00	..... – .....
Silver cyanide	oz.	..... –	1.25 – .....
Silver nitrate	oz.	..... –	.81½ – .82½
Soda ash, light	100 lb.	2.05 –	2.25 – .....
Soda ash, dense	100 lb.	2.25 – 2.50	2.50 – 2.75
Sodium acetate	lb.	.06½ – .07	.07 – .08
Sodium bicarbonate	100 lb.	2.40 –	2.75 – 3.00
Sodium bichromate	lb.	.21½ – .22½	.23 – .25
Sodium bisulphate (nitre cake)	cwt.	6.00 – 7.00	8.00 – 10.00
Sodium bisulphite	ton	7.00 – 8.00	8.50 – 9.00
Sodium borate (borax)	lb.	.08½ – .08¾	..... – .09
Sodium carbonate (sal soda)	100 lb.	1.40 – 1.55	1.50 – 1.75
Sodium chlorate	lb.	.10 –	.12 – .14
Sodium cyanide, 96-98 per cent	lb.	.30 –	.31 – .34
Sodium fluoride	lb.	.14 –	.15 – .16
Sodium hydroxide (caustic soda)	100 lb.	..... –	4.35 – 4.60
Sodium hyposulphite	lb.	..... –	03¾ – .04
Sodium molybdate	lb.	2.50 –	3.25 – .....
Sodium nitrate	100 lb.	3.00 – 3.25	3.75 – 4.00
Sodium nitrite	lb.	.15 – .17	..... – .18
Sodium peroxide, powdered	lb.	..... –	.30 – .32
Sodium phosphate, dibasic	lb.	.03½ – .04½	.04½ – .05
Sodium potassium tartrate (Rochelle salts)	lb.	.40 – .42	.43 – .45½
Sodium prussiate, yellow	lb.	.23 – .29	.30 – .40
Sodium silicate, solution (40 deg.)	lb.	.01½ – .02	.02 – .02½
Sodium silicate, solution (60 deg.)	lb.	.02½ – .03	.05 – .06
Sodium sulphate, crystals (Glauber's salt)	cwt.	1.15 – 1.50	1.60 – 2.00
Sodium sulphide, crystal, 60-62 per cent (conc)	lb.	..... –	.05 – .06
Sodium sulphite, crystals	lb.	.03½ –	.04 – .06
Strontium nitrate, crystals	lb.	.25 –	.28 – .....
Sulphur chloride	lb.	.05½ –	.06 – .....
Sulphur, crude	ton	22.00 –	..... – .....
Sulphur dioxide, liquid, cylinders	lb.	.09 –	.10 – .12
Sulphur (sublimed), flour	100 lb.	3.35 –	3.40 – 3.65
Sulphur, roll (brimstone)	100 lb.	3.20 –	3.30 – 3.40
Tin bichloride (stannous)	lb.	.42½ –	.46 – .50
Tin oxide	lb.	.50 – .60	.65 – .....
Zinc carbonate, precipitate	lb.	..... –	.20 – .....
Zinc chloride, gran.	lb.	.13 –	.13½ – .15
Zinc cyanide	lb.	.49 –	.50 – .....
Zinc dust	lb.	.11¾ – .12½	.13 – .15
Zinc oxide, dry American	lb.	..... –	.09½ – .12
Zinc sulphate	lb.	.03½ – .03¾	.04 – .04½

*Nominal quotations.

Coal-Tar Products

NOTE.—The following prices are for original packages in large quantities:

Alpha naphthol, crude	lb.	$1.00 — $1.10
Alpha naphthol, refined	lb.	1.40 — 1.60
Alpha naphthylamine	lb.	.34 — .42
Aniline oil, drums extra	lb.	.34 — .45
Aniline salts	lb.	.42 — .50
Anthracine, 80% in drums (100 lb.)	lb.	.75 — 1.00
Benzaldehyde (f.f.c.)	lb.	2.00 — 2.10
Benzidine, base	lb.	1.05 — 1.25
Benzidine, sulphate	lb.	.90 — 1.00
Benzoic acid, U.S.P.	lb.	.90 — 1.10
Benzoate of soda, U.S.P.	lb.	.80 — 1.00
Benzol, pure, water-white, in drums (100 lb.)	gal.	.27 — .36
Benzol, 90%, in drums (100 lb.)	gal.	.25 — .29
Benzyl chloride, 95-97%, refined	lb.	.35 — .40
Benzyl chloride, tech.	lb.	.25 — .35
Beta naphthol benzoate	lb.	.50 — .55
Beta naphthol, sublimed	lb.	.65 — .80
Beta naphthol, tech.	lb.	.45 — .55
Beta naphthylamine, sublimed	lb.	2.25 — 2.35
Cresol, U. S. P., in drums (100 lb.)	lb.	.16 — .18
Ortho-cresol, in drums (100 lb.)	lb.	.23 — .25
Cresylic acid, 97-99%, straw color, in drums	gal.	.85 — 1.10
Cresylic acid, 95-97%, dark, in drums	gal.	.80 — 1.00
Cresylic acid, 50%, first quality, drums	gal.	.70 — .....
Dichlorbenzol	lb.	.07 — .10
Diethylaniline	lb.	1.40 — 1.50
Dimethylaniline	lb.	.90 — 1.15
Dinitrobenzol	lb.	.26 — .37
Dinitrochlorbenzol	lb.	.25 — .30
Dinitronaphthaline	lb.	.45 — .55
Dinitrophenol	lb.	.32 — .36
Dinitrotoluol	lb.	.38 — .45
Dip oil, 25%, tar acids, car lots, in drums	gal.	.38 — .40
Diphenylamine	lb.	.55 — .65
H-acid	lb.	1.60 — 1.75
Metaphenylenediamine	lb.	1.15 — 1.80
Monochlorbenzol	lb.	.12 — .15
Monoethylaniline	lb.	1.50 — 1.75
Naphthaline crushed, in bbls. (250 lb.)	lb.	.06 — .08
Naphthaline, flake	lb.	.07 — .08
Naphthaline, balls	lb.	.08½ — .10
Naphthionic acid, crude	lb.	.75 — 1.25
Nitrobenzol	lb.	.14 — .19
Nitro-naphthaline	lb.	.30 — .35
Nitro-toluol	lb.	.20 — .30
Ortho-amidophenol	lb.	3.75 — 4.25
Ortho-dichlor-benzol	lb.	.15 — .20
Ortho-nitro-phenol	lb.	.80 — 1.25
Ortho-nitro-toluol	lb.	.25 — .40
Ortho-toluidine	lb.	.25 — .45
Para-amidophenol, base	lb.	2.50 — 3.50
Para-amidophenol, HCl	lb.	2.50 — 3.25
Para-dichlor-benzol	lb.	.12 — .18
Paranitraniline	lb.	1.00 — 1.35
Para-nitro-toluol	lb.	1.35 — 1.50
Paraphenylenediamine	lb.	2.15 — 3.00
Paratoluidine	lb.	1.75 — 2.50
Phthalic anhydride	lb.	.60 — 1.00
Phenol, U. S. P., drums (dest.), (240 lb.)	lb.	.12 — .25
Pyridin	gal.	2.00 — 2.50
Resorcin, technical	lb.	3.75 — 4.50
Resorcin, pure	lb.	6.50 — 6.75
Salicylic acid, tech., in bbls. (110 lb.)	lb.	.43 — .45
Salicylic acid, U. S. P.	lb.	.55 — .60
Salol	lb.	.90 — .95

Solvent naphtha, water-white, in drums, 100 gal..	gal.	$0.22 —	$0.27
Solvent naphtha, crude, heavy, in drums, 100 gal.	gal.	.19 —	.24
Sulphanilic acid, crude	lb.	.25 —	.30
Toluidine	lb.	1.70 —	2.50
Toluidine, mixed	lb.	.45 —	.55
Toluol, in tank cars	gal.	.28 —	.....
Toluol, in drums	gal.	.29 —	.32
Xylidine, drums, 100 gal.	lb.	.44 —	.50
Xylol, pure, in drums	gal.	.37 —	.45
Xylol, pure, in tank cars	gal.	.35 —	.....
Xylol, commercial, in drums, 100 gal.	gal.	.37 —	.45
Xylol, commercial, in tank cars	gal.	.23 —	.27

Waxes

Prices based on original packages in large quantities.

Beeswax, natural crude, yellow	lb.	$0.42 —	$0.45
Beeswax, refined, yellow	lb.	.47 —	.48
Beeswax, white pure	lb.	.63 —	.68
Carnauba, No. 1	lb.	.80 —	.88
Carnauba, No. 2, regular	lb.	.65 —	.78
Carnauba, No. 3, North Country	lb.	.46 —	.48
Japan	lb.	.18½ —	.20
Paraffine waxes, crude match wax (white) 105-110 m.p.	lb.	.06 —	.07
Paraffine waxes, crude, scale 124-126 m.p.	lb.	..... —	.07
Paraffine waxes, refined, 118-120 m.p.	lb.	..... —	.10¼
Paraffine waxes, refined, 128-130 m.p.	lb.	.09¼ —	.10¼
Paraffine waxes, refined, 133-135 m.p.	lb.	..... —	.13
Paraffine waxes, refined, 135-137 m.p.	lb.	..... —	.14
Stearic acid, single pressed	lb.	.23 —	.26
Stearic acid, double pressed	lb.	.28 —	.29
Stearic acid, triple pressed	lb.	.32 —	.33

NOTE—Quotations on paraffine waxes are nominal.

Flotation Oils

All prices are f.o.b. New York, unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

Pine oil, steam dist., sp. gr., 0.930-0.940	gal.	$1.45
Pine oil, pure, dest. dist	gal.	.....
Pine tar oil, ref., sp. gr. 1.025-1.035	gal.	.40
Pine tar oil, crude, sp. gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.	gal.	.48
Pine tar oil, double ref., sp. gr. 0.965-0.990	gal.	.70
Pine tar, ref., thin, sp. gr., 1.080-1.960	gal.	.38
Turpentine, crude, sp. gr., 0.900-0.970	gal.	1.60
Hardwood oil, f.o.b. Mich., sp. gr., 0.960-0.990	gal.	.35
Pinewood creosote, ref.	gal.	.52

Naval Stores

The following prices are f.o.b., New York, for carload lots.

Rosin B-D, bbl.	280 lb.	$18.15 —	$18.50
Rosin E-I	280 lb.	18.50 —	18.75
Rosin K-N	280 lb.	19.00 —	21.50
Rosin W. G.-W. W.	280 lb.	22.00 —	24.25
Wood rosin, bbl.	280 lb.	17.00 —	17.50
Spirits of turpentine	gal.	..... —	1.97
Wood turpentine, steam dist.	gal.	..... —	1.70
Wood turpentine, dest. dist.	gal.	1.64 —	.....
Pine tar pitch, bbl.	200 lb.	8.25 —	8.50
Tar, kiln burned, bbl. (500 lb.)	bbl.	14.50 —	14.75
Retort tar, bbl.	500 lb.	15.00 —	15.25
Rosin oil, first run	gal.	..... —	.91
Rosin oil, second run	gal.	.93 —	.94
Rosin oil, third run	gal.	1.10 —	1.12
Rosin oil, fourth run	gal.	..... —	1.15

Solvents

73-76 deg., steel bbls. (85 lb.)	gal.	$0.33½
70-72 deg., steel bbls. (85 lb.)	gal.	.31½
68-70 deg., steel bbls. (85 lb.)	gal.	.30½
V. M. and P. naphtha, steel bbls. (85 lb.)	gal.	.23½

Crude Rubber

Para—Upriver fine	lb.	$0.44 —	$0.46
Upriver coarse	lb.	.33 —	.35
Upriver caucho ball	lb.	.33½ —	.34½
Plantation—First latex crepe	lb.	.50 —	.54½
Ribbed smoked sheets	lb.	.49 —	.51
Brown crepe, thin, clean	lb.	.48 —	.48½
Amber crepe No. 1	lb.	.53 —	.....

Oils

VEGETABLE

The following prices are f.o.b., New York for carload lots.

Castor oil, No. 3, in bbls	lb.	$0.18 —	$0.19
Castor oil, AA, in bbls	lb.	.21 —	.23
China wood oil, in bbls	lb.	.23½ —	.24½
Cocoanut oil, Ceylon grade, in bbls	lb.	.21 —	.21½
Cocoanut oil, Cochin grade, in bbls	lb.	.20½ —	.23
Corn oil, crude, in bbls	lb.	.19 —	.22
Cottonseed oil, crude (f.o.b. mill)	lb.	.19 —	.20
Cottonseed oil, summer yellow	lb.	.22 —	.27
Cottonseed oil, winter yellow	lb.	.24½ —	.25½
Linseed oil, raw, car lots	gal.	1.77 —	1.87
Linseed oil, raw, tank cars	gal.	1.70 —	1.80
Linseed oil, boiled, car lots	gal.	1.75 —	1.80
Olive oil, commercial	gal.	2.50 —	2.60
Palm, Lagos	lb.	.17 —	.18
Palm, bright red	lb.	.16½ —	.17½
Palm, Niger	lb.	.16 —	.17½
Peanut oil, crude, tank cars (f.o.b. mill)	lb.	.23½ —	.24
Peanut oil, refined, in bbls	lb.	.27 —	.28
Rapeseed oil, refined in bbls	gal.	1.45 —	1.68
Rapeseed oil, blown, in bbls	gal.	1.60 —	1.70
Soya bean oil (Manchurian), in bbls N. Y.	lb.	.19 —	.23
Soya bean oil, tank cars, f.o.b., Pacific coast	lb.	.17½ —	.20

FISH

Winter pressed Menhaden	gal.	$1.20 —	.....
Yellow bleached Menhaden	gal.	1.23 —	.....
White bleached Menhaden	gal.	1.25 —	.....
Blown Menhaden	gal.	1.26 —	.....

Miscellaneous Materials

All Prices f.o.b., N. Y.

Barytes, domestic, white, floated	ton	$35.00 —	$40.00
Barytes, off color	ton	20.00 —	25.00
Blanc fixe, dry	lb.	.04 —	.05
Blanc fixe, pulp	ton	30.00 —	50.00
Casein	lb.	.16 —	.18
Chalk, English, extra light	lb.	.05 —	.07
Chalk, English, light	lb.	.04½ —	.06
Chalk, English, dense	lb.	.04 —	.05
China clay (Kaolin), imported, lump	ton	25.00 —	35.00
China clay (Kaolin), imported, powdered	ton	30.00 —	60.00
China clay (Kaolin), domestic, lump	ton	10.00 —	20.00
China clay (Kaolin), domestic, powdered	ton	25.00 —	40.00
Feldspar	ton	13.50 —	18.00
Fluor spar, acid grade, lump, f.o.b. mines	net ton	30.00 —	45.00
Fluor spar, acid grade, ground, f.o.b. mines	net ton	50.00 —	52.00
Fuller's earth, domestic, powdered	ton	25.00 —	30.00
Fuller's earth, imported, powdered	ton	35.00 —	40.00
Graphite, crucible, 85% carbon content	lb.	..... —	.07¼
Graphite, crucible, 86% carbon content	lb.	..... —	.07½
Graphite, crucible, 87% carbon content	lb.	..... —	.07¾
Graphite, crucible, 88% carbon content	lb.	..... —	.08
Graphite, crucible, 89% carbon content	lb.	..... —	.08¼
Graphite, crucible, 90% carbon content	lb.	..... —	.08½
Graphite, crucible, 91% carbon content	lb.	..... —	.08¾
Graphite, crucible, 92% carbon content	lb.	..... —	.09
Graphite, crucible, plus 92%		..... —	.12
Pumice stone, imported	lb.	.03 —	.06
Pumice stone, domestic	lb.	.02½ —	.....
Shellac, orange, fine	lb.	1.25 —	.....
Shellac, orange, superfine	lb.	1.20 —	1.30
Shellac, A. C. garnet	lb.	1.10 —	.....
Soapstone	ton	15.00 —	25.00
Talc, domestic	ton	16.00 —	60.00
Talc, imported	ton	60.00 —	70.00

Refractories

Following prices are f.o.b. works:

Chrome brick	net ton	75-80 at Chester, Penn.
Chrome cement	net ton	45-50 at Chester, Penn.
Clay brick, 1st quality fireclay	1,000	38-45 at Clearfield, Penn.
Clay brick, 2nd quality	1,000	33-35 at Clearfield, Penn.
Magnesite, dead burned	net ton	50-55 at Chester, Penn.
Magnesite brick, 9 x 4½ x 2½ in.	net ton	80-85 at Chester, Penn.
Silica brick	1,000	45-50 at Mt. Union, Penn.

Ferro-Alloys

All Prices f.o.b. works

Ferro-carbon-titanium, 15-18%, f.o.b. Niagara Falls, N. Y.	net ton	$200.00 —	$250.00
Ferro-chrome, per lb. of Cr. contained, 6-8% carbon	lb.	.20 —	.40
Ferro-chrome, per lb. of Cr. contained, 2-4% carbon	lb.	.21 —	.50
Ferro-manganese, 70-80% Mn	gross ton	150.00 —	165.00
Spiegeleisen, 16-20% Mn	gross ton	40.00 —	55.00
Ferro-molybdenum, per lb. of Mo	lb.	3.00 —	3.50
Ferro-silicon, 50%	gross ton	85.00 —	95.00
Ferro-silicon, 75%	gross ton	150.00 —	175.00
Ferro-silicon, 10-15%	gross ton	45.00 —	60.00
Ferro-tungsten, 70-80%, per lb. of contained W	lb.	1.25 —	1.40
Ferro-uranium, 35-50%, of U	lb.	7.00 —	.....
Ferro-vanadium, 30-40% per lb. of contained V	lb.	5.50 —	7.00

Ores and Semi-finished Products

Chrome ore, 35-40%, Cr_2O_3	unit	$0.60 —	$0.85
Chrome ore, 48% and over	unit	1.00 —	1.25
*Coke, foundry, f.o.b. ovens	net ton	7.00 —	7.50
*Coke, furnace, f.o.b. ovens	net ton	6.00 —	6.50
Petroleum coke, refinery, Atlantic seaboard	net ton	..... —	14.00
Fluor spar, gravel, f.o.b. mines	net ton	..... —	25.00
Manganese ore, 45% Mn and over	unit	.50 —	.75
Manganese ore, chemical (MnO_2)	gross ton	60.00 —	70.00
Molybdenite, 85% MoS_2, per lb. of MoS_2	lb.	.75 —	.85
Tungsten, Scheelite, 60% WO_3 and over, per unit of WO_3	unit	9.00 —	15.00
Tungsten, Wolframite, 60% WO_3 and over, per unit of WO_3	unit	7.50 —	10.00
Uranium oxide, 96%	lb.	2.75 —	3.00
Vanadium pentoxide, 99%	lb.	6.00 —	.....
Pyrites, foreign, lump	unit	.17 —	.....
Pyrites, foreign, fine	unit	.17 —	.....
Pyrites, domestic, fine	unit	.16 —	.17½
Ilmenite, 52% TiO_2	lb.	.02 —	.....
Rutile, 95% TiO_2	lb.	.11 —	.....
Carnotite, minimum 2% U_3O_8, per lb. of U_3O_8	lb.	2.75 —	3.00
Zircon, washed, iron free	lb.	.10 —	.....
Monazite, per unit of ThO_2	unit	42.00 —	.....

*Government prices.

Structural Steel

Mill, Pittsburgh

Beams and channels, 3 to 15-in.	100 lb.	$2.45
Angles, 3 to 6-in., ¼-in. thick	100 lb.	2.45
Tees, 3-in. and larger	100 lb.	2.45
Plates	100 lb.	2.65
Rivets, structural, ¾-in. and larger	100 lb.	4.20
Rivets, conehead for boilers, ¾-in. and larger	100 lb.	4.30
Sheets, No. 28 black	100 lb.	4.85
Sheets, No. 10 blue annealed	100 lb.	4.00
Sheets, No. 28 galvanized	100 lb.	6.20

For painted corrugated sheets, add 30c. per 100 lb. for 25 to 28 gage; 25c. for 19 to 24 gage; for galvanized corrugated sheets, add 15c., all gages.

INDUSTRIAL

Financial, Construction and Manufacturers' News

Construction and Operation

California

BANNING—The city has granted a franchise to the Twin Cities Gas Co., recently organized by the Union Natl. Bank of Pasadena, J. M. Berkley, engr., Hollingsworth Bldg., Los Angeles, and others, to reconstruct and enlarge the old gas plant and distributing system. Estimated cost, $27,500. Work will probably be done by day labor.

MERIDIAN—The Alameda Sugar Co., 310 Sansome St., San Francisco, plans to build a sugar refinery, here. Estimated cost, $1,500,000.

SANTA ANA—The Holly Sugar Co. has awarded the contract for the construction of a 2-story, 60x100-ft. sugar factory near here, to Leonard & Peck, 721 H. W. Hellman Bldg., Los Angeles. Estimated cost, $70,000.

VENTURA—The Shell Oil Co. of Ventura plans to build a refinery on its Gosnell lease near here. Estimated cost, $60,000.

Illinois

CHICAGO—The Flexible Steel Lacing Co., 522 South Clinton St., is having plans prepared for the construction of a 1-story, 200x200-ft. factory on Polk St. along the Belt Line R.R. Estimated cost, $200,000. W. G. Carnegie, 189 West Washington St., archt.

CHICAGO—H. C. Miller, archt., 112 West Adams St., will soon award the contract for the construction of a 3-story, 120x140-ft. paper box factory at 1701 Superior St., for the Kroeck Paper Box Co., 220 Institute Pl. Estimated cost, $175,000.

Iowa

DENTER—H. H. Hough, town clk., will receive bids until Feb. 26 for the construction of a sanitary sewerage system and disposal plant. T. S. DeLay, Creston, consult. engr. Noted Sept. 1.

SCRANTON—L. V. E. Peterson, town clk., will receive bids until March 4, for the construction of a sanitary sewerage system and disposal plant. T. S. DeLay, Creston, consult. engr.

Louisiana

NEW ORLEANS—The Simms Oil Co., Shreveport, plans to construct a 20,000-bbl. refinery above New Orleans on the tidewater terminus, including 280 mi. of 8-in. pipe line from here to Sibley, Claiborne Parish. Estimated cost, $12,000,000. C. B. Denning, pres.

Michigan

ANN ARBOR—The University of Michigan has awarded the contract for the construction of a 6-story hospital on East Anne St., including a 3-story, 56x153-ft. administration building; 51x254-ft. surgical wing, 44x58-ft. demonstration wing and a 35x420-ft. main hospital building with 2 wings, 35x112-ft. and 35x88-ft., to Thompson-Starrett Co., 702 Lincoln Bldg., Detroit. Laboratory equipment will be installed in same. Estimated cost, $1,000,000.

DETROIT—The Bd. of Water Comrs. 232 Jefferson Ave., will soon award the contract for the construction of the substructure for a low lift pumping station. This is the first unit in the construction of a filtration plant to cost over $5,000,000. T. A. Leisen, Waterworks Park, engr.

Nebraska

BROKEN BOW—F. M. Skillman, city clk., has awarded the contract for the construction of a sewerage system, including a disposal plant, to Smith & Chambers, Scotts Bluff. Estimated cost, $167,000. Noted Sept. 14.

New York

BUFFALO—The Dunlap Rubber Co., 1808 B'way, New York City, has awarded the contract for the construction of twelve 1- and 2-story factory buildings, to the Foundation Co., 233 B'way, New York City. Estimated cost, $20,000,000.

BUFFALO—The University of Buffalo, 24 High St., plans to construct a 2-story laboratory addition. Estimated cost, $68,000.

NEW YORK—The Standard Lithographing Co., 1100 Brook Ave., will build a 6-story, 50x118-ft. factory at Brook Ave. and 167th St. Estimated cost, $75,000. Work will be done by day labor.

North Carolina

LEXINGTON—The city rejected all bids for the construction of a water system, including filter house, installation of filter tubs, coagulating basin, etc. G. C. White, Durham, engr. Work will be readvertised.

Ohio

ASHLAND—The city is having plans prepared for the construction of a 1-story, 40x60-ft. superstructure for the filtration plant and is in the market for filter equipment. Estimated cost, $60,000. R. Winthrop Pratt, Hippodrome Bldg., Cleveland, engr.

CLEVELAND—The Buckeye Brass Co., 6410 Hawthorne Ave., is having plans prepared for the construction of a 1-story, 30x110-ft. foundry and a 75x75-ft. furnace room on Ashland Rd. Estimated cost, $50,000. Nathan Carl, secy. Allen Sogg, 319 Hippodrome Bldg., archt.

CLEVELAND—The Cleveland Window Glass & Door Co., 209 Champlain Ave., will build a 1-story, 50x72-ft. mill at 2421 Elm St. Estimated cost, $10,000. Work will be done by day labor.

CLEVELAND — Friedman-Blaw-Farber Co., East 37th St. and Perkins Ave., has awarded the contract for the construction of a 6-story, 57x85x127-ft. addition for the manufacture of knit goods, to the Craig-Curtiss Co., 1031 Guardian Bldg. Estimated cost, $200,000.

COLUMBUS—The Bd. Comrs. Franklin Co., Court House, will receive bids until March 4 for the construction of a 2-story tuberculosis hospital on the Infirmary Grounds. Estimated cost, $125,000. W. H. Tremaine, 602 Chamber of Commerce Bldg., archt.

COLUMBUS—The Ohio Wax Paper & Printing Co., 22nd and Frebis Sts., has awarded the contract for the construction of a 1-story, 111x157-ft. factory on Hartford St., to A. H. Leibrand, 262 Donaldson St. Estimated cost, $45,000.

Oklahoma

PAWHUSKA—The Le Flore Oil & Gas Co., Tulsa, plans to build a refinery, here. Estimated cost, $300,000.

TULSA—The Petroleum Club of Tulsa plans to construct a 6-story clubhouse. Estimated cost, $250,000.

TONKAWA—The city plans to improve the waterworks system, including the testing for underground infiltration gallery. Estimated cost, $75,000. Johnson & Benham, Firestone Bldg., Kansas City, Mo., engrs.

Pennsylvania

LOCK HAVEN—The Pensylvania Paper Co. plans to construct a 3-story, 100x300-ft. paper mill on North St., to have a daily capacity of 120 tons of paper. Estimated cost, $3,000,000.

PHILADELPHIA—Franklin & Co., archt. and engr., Crozer Bldg., will soon award the contract for the construction of a 2-story, 38x53-ft. factory building at 10th and Pearl Sts., for the Jarden Lithographing Co., 310 North 11th St. Estimated cost, $20,000.

Washington

SEATTLE—The Western Paper Goods Co., Collins Bldg., has awarded the contract for the construction of a 1-story, 90x103-ft. factory at 1401 Dexter Ave., to Johnson Bros., Hoge Bldg. Estimated cost, $15,000.

Wisconsin

MILWAUKEE—The Central Bd. Purchases, City Hall, will soon award the contract for furnishing 35,000 lb. c.p. anhydrous liquid chlorine for the Water Dept.

WAUKESHA—The Waukesha Cement Tile Co., 102 Main St., plans to build 1-story, 132x136-ft. factory. Estimated cost, $45,000. Work will probably be done by day labor.

Ontario

BRANTFORD — The Dominion Steel Products Co. plans to construct a 1-story, 60x80x100-ft. foundry. Estimated cost, $150,000.

TORONTO—The Canadian Natl. Carbon Co. is having plans prepared for the construction of a factory for the manufacture of oxygen, tanks and oxygen products. Estimated cost, $100,000. Leighton McCarthy, 265 Adelaide St., W., pres.

Coming Meetings and Events

THE AMERICAN ASSOCIATION OF ENGINEERS will hold its fifth annual convention at the Planters Hotel in St. Louis, May 10 and 11.

THE AMERICAN CERAMIC SOCIETY will hold its annual meeting in Philadelphia, Pa., Feb. 23 to 26. Headquarters are at the Bellevue-Stratford Hotel.

THE AMERICAN CHEMICAL SOCIETY will hold its annual meeting April 13 to 16 inclusive, in St. Louis. Headquarters will be at the Hotel Statler.

THE AMERICAN ELECTROCHEMICAL SOCIETY will hold its spring meeting in Boston, April 8, 9 and 10. Headquarters will be at the Copley-Plaza Hotel.

THE AMERICAN ELECTROCHEMICAL SOCIETY, NEW YORK SECTION, will have a meeting on Feb. 27, the subject for which is "Electric Furnace Reducing Agents." Another meeting will be held on March 26, the subject of which is "Peace Uses for War Products."

THE AMERICAN INSTITUTE OF CHEMICAL ENGINEERS will hold its semi-annual meeting in Montreal, June 21 and 22; Ottawa, June 23; Shawinigan, June 24 and 25, and La Tuque, June 26.

THE AMERICAN INSTITUTE OF MINING AND METTALURGICAL ENGINEERS is holding its spring meeting in New York this week.

THE AMERICAN PETROLEUM LEAGUE will hold a meeting in Chicago, March 26 to 29.

THE CANADIAN MINING INSTITUTE will hold its annual meeting at the King Edward Hotel, Toronto, March 8 to 10.

THE FARADAY SOCIETY (London) will hold a joint meeting, March 1, with the London Section of the Society of Chemical Industry to receive and discuss a report of Dr. T. Martin Lowry, and E. C. Hemmings on the "Setting of Salts and Other Crystalline Substances." Another meeting will be held March 23, at which there will be a general discussion on "Basic Slag From the Metallurgical and Agricultural Standpoints."

THE INSTITUTE OF METALS will hold its annual general meeting March 11 and 12 at the Institution of Mechanical Engineers, Storey's Gate, Westminster, S. W. 1, London, England.

THE IRON AND STEEL INSTITUTE (London) will hold its annual meeting May 6 and 7, 1920, at the House of the Institute of Civil Engineers, Great George St., London, S. W. 1. The retiring president, Eugene Schneider, will induct into the chair Dr. J. E. Stead, the president-elect.

THE MATERIAL HANDLING MACHINERY MANUFACTURERS' ASSOCIATION will hold its convention at the Waldorf-Astoria Hotel, New York City, Feb. 26 and 27.

THE NATIONAL FERTILIZER ASSOCIATION will hold its twenty-seventh annual convention at the Greenbrier, White Sulphur Springs, W. Va., the week of June 21.

THE NATIONAL FOREIGN TRADE CONVENTION will be held in San Francisco, May 12 to 15.

THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY will hold its spring meeting at the Hotel Waldorf and the Hotel Astor, New York City, April 12 to 16.